Award List for ANTARCTIC GLACIOLOGY (current as of 7/02)

Julie Palais, Program Manager (jpalais@nsf.gov)

9526421 *Recovery and Science Coordination of an Ice Core at Siple Dome, Antarctica*

Original Start Date:**Jun 01, 1996** Projected Duration:**60 Months**
PI: **Taylor** Institution:**U of Nevada Desert Res Ins** State:**Nevada**

This award is for support for the recovery of a 1000-meter ice core from Siple Dome, Antarctica and the coordination of a science management office for the scientific program. The proposed project is part of the West Antarctic Ice Sheet (WAIS) program, which seeks to understand the current behavior of the West Antarctic ice sheet and to decipher its past climate history. Siple Dome is located between ice streams C and D and is well-situated to investigate coastal climate conditions and the dynamics of the Siple Coast ice streams which drain the West Antarctic ice sheet. The annual accumulation at the site is 7 to 11 cm of ice per year and it is anticipated that annual layers will be identifiable to an age of at least 6,000 years before present. The length of the usable climate record will extend to at least 80,000 years before present. This proposal provides the background for the Siple Dome drilling program and develops the opportunity for individual scientists (who have submitted separate proposals) to work on the ice core . This proposal would establish a Science Coordination Office that would coordinate the activities of the various organizations involved in the project, including the National Science Foundation (NSF), the Polar Ice Coring Office (PICO), Antarctic Support Associates (ASA), and the National Ice Core Laboratory (NICL).

9526420 *Electrical and Optical Measurements on the Siple Dome Ice Core*

Original Start Date:**Mar 01, 1996** Projected Duration:**60 Months**
PI: **Taylor** Institution:**U of Nevada Desert Res Ins** State:**Nevada**

This award is for support for the measurement of electrical and optical properties of the Siple Dome ice core. The electrical methods can be used to determine the concentration of the hydrogen ions and the concentration of a weighted sum of all ions. The electrical measurements can resolve features as small as 1 cm. The albedo of the core is also measured with a laser system that can resolve features as small as 0.5 cm. The high spatial resolution of these methods makes them

ideal for resolving narrow features in the core, which can be missed in larger composite samples. The measurements will be particularly useful for assisting to date the core and to identify short duration features in the record, such as volcanic eruptions. These measurements will also provide useful information for assessing the temporal variability of Holocene accumulation rate and atmospheric circulation.

9634659 *Operation and Maintenance of the U.S. National Ice Core Laboratory*

Original Start Date:**Mar 01, 1996** Projected Duration:**80 Months**
PI: **Fitzpatrick** Institution:**Geological Survey** State:**Virginia**

This award is for support for the operations and maintenance of the U.S. National Ice Core Laboratory, hereinafter called "NICL" a government-owned facility for storing, curating, and studying ice cores recovered from the ice-covered regions of the world. NICL provides NSF- and USGS-funded investigators with the capability to conduct examinations and measurements of ice cores while preserving the integrity of these cores in a safeguarded environment. NICL fosters the utilization of these cores for scientific research by handling inquiries from scientists interested in obtaining samples of ice cores, by making inventory listings easily available through electronic distribution, by acting as an information resource to the scientific community and by improving current technologies for ice core analysis in accordance with the needs and requirements of their client base. NICL is located at the Denver Federal Center in Lakewood, Colorado and is housed administratively within the USGS Office of the Central Regional Geologist, Geologic Division

9615502 *Ice Dynamics, the Flow Law, and Vertical Strain at Siple Dome*

Original Start Date:**Mar 01, 1997** Projected Duration:**36 Months**
PI: **Harrison** Institution:**U of Alaska Fairbanks** State:**Alaska**

This award is for support for a three year project to measure the vertical strain rate as a function of depth at two sites on Siple Dome Antarctica. Ice flow near a divide such as Siple Dome is unique in that it is predominantly vertical. As a consequence, the component of ice deformation in the vertical direction, the "vertical strain rate" is dominant. Its measurement is therefore important for the calibration of dynamic models of ice flow. Two different, relatively new, high resolution systems for its measurement in hot water drilled holes will be employed. The ice flow model resulting from the measurements and flow law determination will be used to interpret the shapes of radar internal layering in terms of the dynamic history and accumulation patterns of Siple Dome over the

past 10,000 years. The resulting improved model will also be applied to the interpretation of annual layers thicknesses (to produce annual accumulation rates) and borehole temperatures from the ice core to be drilled at Siple Dome during the 1997/98 field season. The results should permit an improved analysis of the ice core, relative to what was possible at recent coring sites in central Greenland. This is a collaborative project between the University of Alaska, the University of California, San Diego and the University of Washington.

9615420 *Basal Conditions of Ice Stream D and Related Borehole Studies of Antarctic Ice Stream Mechanics*

Original Start Date:**Jul 01, 1997** Projected Duration:**60 Months**
PI: **Kamb** Institution:**California Inst of Tech** State:**California**

This award is for support for a four year program to study the basal conditions of ice stream D using techniques previously applied to ice stream B. The objective is to determine whether the physical conditions and processes to be observed by borehole geophysics at the base of this large ice stream are consistent with what has been observed at ice stream B and to point to a common basal mechanism of ice streaming. This project includes a comparison between two parts of ice stream D, an upstream reach where flow velocities are modest (about 80 meters/year) and a downstream reach of high velocity (about 400 meters/year). The comparison will help to reveal what physical variable or combination of variables is mainly responsible for the streaming flow. The variables to be monitmred by borehole observation include basal water pressure, basal sliding velocity, flow properties and sedimentological characteristics of subglacial till if present, ice temperature profile including basal water transport velocity, connection time to the basal water system, basal melting rate and others.

9615417 *Ice Dynamics, the Flow Law, and Vertical Strain at Siple Dome*

Original Start Date:**Mar 15, 1997** Projected Duration:**36 Months**
PI: **Waddington** Institution:**U of Washington** State:**Washington**

This award is for support for a three year project to measure the vertical strain rate as a function of depth at two sites on Siple Dome Antarctica. Ice flow near a divide such as Siple Dome is unique in that it is predominantly vertical. As a consequence, the component of ice deformation in the vertical direction, the "vertical strain rate" is dominant. Its measurement is therefore important for the calibration of dynamic models of ice flow. Two different, relatively new, high resolution systems for its measurement in hot water drilled holes will be employed. The ice flow model resulting from te measurements and flow law

determination will be used to interpret the shapes of radar internal layering in terms of the dynamic history and accumulation patterns of Siple Dome over the past 10,000 years. The resulting improved model will also be applied to the interpretation of annual layers thicknesses (to produce annual accumulation rates) and borehole temperatures from the ice core to be drilled at Siple Dome during the 1997/98 field season. The results should permit an improved analysis of the ice core, relative to what was possible at recent coring sites in central Greenland. This is a collaborative project between the University of Alaska, the University of California, San Diego and the University of Washington.

9615167 *Collaborative Research: Volcanic Records from the Siple and Taylor Dome Ice Cores, Antarctica*

Original Start Date:**Apr 15, 1997** Projected Duration:**48 Months** PI: **Dunbar** Institution:**NM Inst of Mining & Tech** State:**New Mexico**

(9614384 Zielinski 9615167 Dunbar) This award supports a project to characterize the volcanic material in the Siple Dome and Taylor Dome ice cores. The time series of volcanic aerosol and tephra deposition available in high-resolution, bi-polar ice cores is the most reliable means of developing continuous and lengthy records of past volcanic activity and assessing the climatic and environmental impact of global volcanism. The volcanic records from the Siple Dome ice core, initial ice core in the West Antarctica Ice Core Program (WAISCORES), and the Taylor Dome core, recently collected from the Transantarctic Mountains, will provide the Southern Hemisphere component of this record. These results will complement the lengthy GISP2 volcanic record from Greenland. Annual resolution should be available in the Siple Dome core for the Holocene resulting in the longest volcanic record with such resolution from Antarctica. Total length of record thought to be available from the Siple Dome core is 80,000 years whereas that for the Taylor Dome core is probably over 100,000 years. Although temporal resolution will be much coarser in the glacial portion of the Siple Dome core and in much of the Taylor Dome core, correlations and comparisons of the volcanic records from those cores with those from the GISP2 core are still possible. Evaluation of the timing of the volcanic signals in relationship to the record of changing climatic conditions available in these ice cores provides critical information on the climate forcing capabilities of global volcanism on decadal to century time scales through the Holocene. The key to developing a reliable chronology of past volcanism from the Siple Dome core is the simultaneous and continuous measurement of SO_4^{2-}, a direct measure of the volcanic H_2SO_4 produced from the eruption, and the search for tephra in the same subsamples over the entire length of the core. The glaciochemical record will be available through other investigator s in the Siple Dome project. The glaciochemical record for the Taylor Dome core is presently available. Locating tephra and identifying the source of the volcanic glass through both optical

microscope and microbeam (both electron and ion microprobes) analyses will verify the source of the chemical signal and help differentiate between equatorial and local eruptions. Comparisons with the GISP2 volcanic record will assist in achieving this goal. This multiparameter approach to deciphering the volcanic record will improve on our understanding of the influence of volcanism on climate both interhemispherically and intrahemispherically. The correlation of tephra found in these cores with that found in marine sediments and in the terrestrial record will expand on the chronology of global volcanism and improve the correlation among ice core, marine, and terrestrial proxy climatic records. Visible tephra layers that should exist in the Siple Dome core and do exist in the Taylor Dome core will provide additional absolute time lines for possible correlations between the two cores, among previously collected Antarctica ice cores and with tephra studies in blue ice areas of Western Antarctica and the Transantarctic Mountains.

9726113 *Collaborative Research: WAIS Ice Divide Migration*

Original Start Date:**May 01, 1998** Projected Duration:**36 Months**
PI: **Waddington** Institution:**U of Washington** State:**Washington**

This award supports a project to use airborne ice penetrating radar and topographic information to map internal layering of the divide zone between the Amundsen Sea and Ross Embayment to search for evidence of divide migration. If collapse has been in progress for some time, it should be detectable in distortions of the layering. The project will use the Support Office for Aerogeophysical Research (SOAR) Twin Otter aircraft to map the ice along flow lines which cross the divide. The data will be used together with ice flow models to infer an ice divide migration history, obtain information about recent accumulation rate over planned traverse routes and will provide important information on time scale and layer thickness for the inland West Antarctic ice sheet ice coring project

9726078 *High Precision Borehole Temperature Measurements at Siple Dome, Antarctica, for Paleoclimate Reconstruction and Ice Dynamics Studies*

Original Start Date:**Apr 01, 1998** Projected Duration:**36 Months**
PI: **Waddington** Institution:**U of Washington** State:**Washington**

This award supports a project to obtain a number of high- precision borehole temperature profiles at Siple Dome for paleoclimate reconstruction and ice dynamics studies. Continuous temperature logs will be obtained in the 1 km deep fluid-filled Siple Dome borehole and in several 160 m deep holes along a 20 km north-south transect across Siple Dome. The borehole temperature data will be

used to: a) establish the conductive heat flux across the basal interface of the ice sheet, b) reconstruct the surface temperature history at Siple Dome using geophysical inverse methods ("borehole paleothermometry"), c) constrain how thick the ice sheet was during the late Wisconsin, the magnitude of the Wisconsin/Holocene deglacial warming, and the background geothermal heat flux, d) determine the calibration constants for the oxygen-isotope paleothermometer at Siple Dome in the past, and e) establish the spatial variability of surface temperature on the 20 km scale near the main drill site during the last 100 years. The results at Siple Dome are expected to provide data needed to assess the short-term stability of the West Antarctic Ice Sheet, improve our understanding of the magnitude of past temperature changes at this southern hemisphere site, and lead to improved estimates of the pore close-off ages in the past which should lead to an improved age scale for the Siple Dome ice core.

9725360 *Distribution of Motion Beneath Soft-Bedded Glaciers: Laboratory Studies of Till Deformation and Non-Hydrostatic Pore Pressure*

Original Start Date:**May 15, 1998** Projected Duration:**48 Months**
PI: **Iverson** Institution:**Iowa State University** State:**Iowa**

This award supports a program to conduct experiments with a ring-shear device that deforms a large water-saturated till specimen to high strains, for studies of till comminution, rheology, and fabric development. Despite the widespread realization that subglacial sediment affects the dynamics of ice sheets, the factors that control the sediment mass balance remain obscure. Direct measurements beneath a handful of glaciers seem to indicate a wide range of behavior, varying from pervasive deformation of the bed to motion that is focused at the glacier sole. The interpretation of these measurements and the accurate modeling of basal sediment transport requires laboratory studies aimed at revealing the fundamental factors that control the distribution of motion at the glacier bed.

9818734 *Seasonal, Interannual, and Long-Term Elevation Change of the East Antarctic Ice Sheet from Satellite Radar Altimetry*

Original Start Date:**Oct 01, 1998** Projected Duration:**36 Months**
PI: **Davis** Institution:**U of Missouri Columbia** State:**Missouri**

Early indications of climate change in the polar regions can be detected by monitoring the surface properties of the polar ice sheets. Time series of ice-sheet surface elevations from satellite radar altimeters can be used to study the mass

balance of the ice sheets. Short-term changes in surface elevation are caused by seasonal and interannual variations in snow accumulation and melting, while longer-term elevation changes are linked to climate change and global sea levels. This proposal requests support to document long-term elevation change of the East Antarctic ice sheet using radar altimeter data from Seasat, Geosat, and Geosat-Follow On (GFO) satellites. As a direct consequence of this goal, it will also be necessary to quantify seasonal and interannual variations in ice-sheet elevation to place the long-term measurements in context. This work is a direct extension of similar work done on the Greenland ice sheet and will incorporate methods and techniques already proven to produce substantial improvement in measurement accuracy. This work will provide important baseline information that will significantly enhance the interpretation of measurements from NASA's Geoscience Laser Altimeter System (GLAS) scheduled for launch in 2001.

9818622 *Analysis of Antarctic Ice-Shelf Rifting, Calving and Ice-Front Ocean Interaction Using SAR Interferometry, Ice-Shelf Thermomechanical Models and Ocean Tidal Models*

Original Start Date:**Oct 01, 1998** Projected Duration:**36 Months**
PI: **MacAyeal** Institution:**University of Chicago** State:**Illinois**

This award is to support a study of Antarctic ice-shelf rifting, calving, and ice-front ocean interaction using synthetic aperture radar (SAR) interferometry, ice-shelf thermomechanical models and ocean tidal models. The mass balance of the Antarctic ice sheet is governed in large part by iceberg calving from the large-scale ice shelves which surround the ice sheet's seaward perimeter. This work is designed to develop an understanding of ice-shelf flow and rifting processes. The recent break-up of the northernmost portion of the Larsen Ice Shelf suggests that ice shelves can catastrophically disintegrate in response to environmental change by a "disaggregation" process involving pre-existing detachment rifts. This work will address the question of whether similar break-up could be possible for the larger Filchner-Ronne and Ross ice shelves. The existence of rifts is believed to be a necessary condition for sudden ice-shelf break-up, and processes such as meltwater formation and surface ponding are believed to be the additional sufficient (enabling) condition that causes rifts to separate. The focus of this study will be on the governing tidal and creep-flow processes by which rifts are created. This study will involve synthetic aperture radar (SAR) interferometry, finite difference modeling of ocean tides, and finite-element thermomechanical modeling of ice-shelf creep flow. The processes that govern ice-shelf fracture, calving, flow and interaction with the ocean and atmosphere will be investigated.

9818513 *Satellite Image Analyses for US ITASE Route Selection and Sampling Strategy*

Original Start Date:**Oct 01, 1998** Projected Duration:**36 Months**
PI: **Hamilton** Institution:**Ohio State Univ Res Fdn** State:**Ohio**

This award is for a program of satellite image analysis in support of the U.S. component of the International Trans-Antarctic Scientific Expedition (ITASE). Imagery will be used to select the safest traverse routes and good locations for ice core drilling. RADARSAT imagery is proposed as the primary tool for crevasse mapping. The search for good ice core drilling sites will involve determining local slope fluctuations, ice flow directions, orientation and intensity of buried sastrugi and evidence of past melt near potential drill sites. The work is directly relevant to understanding the mass balance of the Antarctic Ice Sheet and will help in the interpretation of the ice core records collected as part of ITASE

9815200 *Stable Isotope Studies at West Antarctic ITASE Sites*

Original Start Date:**Mar 01, 1999** Projected Duration:**60 Months**
PI: **White** Institution:**U of Colorado Boulder** State:**Colorado**

This collaborative proposal supports a project to perform stable isotope analyses of samples collected along the International Trans-Antarctic Scientific Expedition (ITASE) traverses which will begin during the 1999/2000 Antarctic field season. This work will focus on the spatial and temporal distribution of oxygen-18 and deuterium in West Antarctica (where data are particularly sparse) and the calibration of the isotope-climate relationship on a site-by-site basis, using instrumental and remote-sensing temperature histories. Specific objectives of this work which contribute to ITASE are: 1) to obtain detailed oxygen-18, deuterium and deuterium excess and stratigraphic histories in snowpits at most or all of the ITASE coring sites; 2) to provide direct calibration of the isotope-climate relationship at each site through a combination of direct (AWS) and indirect (passive microwave satellite) temperature measurements; 3) to obtain isotope profiles covering the last 200 years; and 4) to use the results to provide 200-year climate histories at high temporal and broad spatial resolution across West Antarctica that will allow testing of proposed relationships among isotopes, moisture source conditions, synoptic scale climatology, and site-specific meteorological parameters, and which will enhance our ability to interpret isotope records from older and deeper Antarctic ice cores.

9815160 *Anisotropic Flow, Depth-Age Relationships and Stratigraphic Disturbances in Polar Ice Sheets: Collaborative Research by University of Washington and University of Colorado*

Original Start Date:**Jul 01, 1999** Projected Duration:**36 Months**
PI: **Fletcher** Institution:**U of Colorado Boulder** State:**Colorado**

This award supports a collaborative program to bring together glaciology and structural geology to tackle two related cross-disciplinary issues. The project will investigate the geological mechanisms known to operate in anisotropic rocks that may also generate stratigraphic disruptions in polar ice. A series of analytical and semi-analytical models to explore conditions for and onset of folding, kinking, fabric striping, and shear banding in polar ice sheets will be developed using linearization and perturbation methods. A fundamental goal is a new ability to estimate the maximum depths of undisturbed ice for ice cores in various settings. The bulk anisotropic properties of polar ice will also be incorporated in a new finite element dynamic ice flow model. One goal is to extend the models of layer disruption processes to large strains. This model will also be used to improve the predicted depth-age relationships for ice core sites, and to produce improved calculations of the thinning functions needed to convert measured layer thicknesses to past accumulation rates for deep ice that has a strongly anisotropic bulk fabric.

9815136 *Anisotropic Flow, Depth-age Relationships and Stratigraphic Disturbances in Polar Sheets: Collaborative Research by the Universities of Washington and Oregon*

Original Start Date:**Jul 01, 1999** Projected Duration:**36 Months**
PI: **Waddington** Institution:**U of Washington** State:**Washington**

This award supports a collaborative program to bring together glaciology and structural geology to tackle two related cross-disciplinary issues. The project will investigate the geological mechanisms known to operate in anisotropic rocks that may also generate stratigraphic disruptions in polar ice. A series of analytical and semi-analytical models to explore conditions for and onset of folding, kinking, fabric striping, and shear banding in polar ice sheets will be developed using linearization and perturbation methods. A fundamental goal is a new ability to estimate the maximum depths of undisturbed ice for ice cores in various settings. The bulk anisotropic properties of polar ice will also be incorporated in a new finite element dynamic ice flow model. One goal is to extend the models of layer disruption processes to large strains. This model will also be used to improve the predicted depth-age relationships for ice core sites, and to produce improved calculations of the thinning functions needed to convert measured layer thicknesses to past accumulation rates for deep ice that has a strongly anisotropic bulk fabric.

9814816 *Collaborative Research: Characterizing the Onset of Ice Stream Flow: A Ground Geophysical Field Program*

Original Start Date:**Sep 15, 2000** Projected Duration:**48 Months** PI: **Blankenship** Institution:**U of Texas Austin** State:**Texas**

This award supports a four year project to develop of better understanding the ice streams of the Ross Sea Embayment (A--F) which drain the interior West Antarctic Ice Sheet (WAIS) by rapidly moving vast quantities of ice to the calving front of the Ross Ice Shelf. The project will examine the role of these ice streams as buffers between the interior ice and the floating ice shelves. The reasons for their fast flow, the factors controlling their current grounding-line-, margin-, and head-positions are crucial to any attempt at modeling the WAIS system and predicting the future of the ice sheet. For the Antarctic ice streams of the Siple Coast, the transition from no-sliding (or all internal deformation) to motion dominated by sliding is defined as the "onset-region". To fully understand (and adequately model) the WAIS, this onset region must be better understood. The lateral margins of the ice streams are also a transition that need better explanation. Hypotheses on controls of the location of the onset region range from the "purely-glaciologic" to the "purely-geologic. Thus, to model the ice sheet accurately, the basal boundary conditions (roughness, wetness, till properties) and a good subglacial geologic map, showing the distribution, thickness, and properties of the sedimentary basins, are required. These parameters can be estimated from seismic, radar, and other geophysical methods. The transition region of ice stream D will be studied in detail with this coupled geophysical experiment. In addition, selected other locations on ice streams C & D will be made, to compare and contrast conditions with the main site on ice stream D. Site-selection for the main camp will be based on existing radar, GPS, and satellite data as well as input from the modeling community.

9814810 *Hydrogen Peroxide, Formaldehyde, and Sub-Annual Snow Accumulation in West Antarctica: Participation in West Antarctic Traverse*

Original Start Date:**Mar 01, 1999** Projected Duration:**60 Months** PI: **Bales** Institution:**U of Arizona** State:**Arizona**

This award supports a project to improve understanding of atmospheric photochemistry over West Antarctica, as recorded in snow, firn and ice. Atmospheric and firn sampling will be undertaken as part of the U.S. International Trans-Antarctic Scientific Expedition (US ITASE) traverses. Measurements of

hydrogen peroxide (H_2O_2) and formaldehyde (HCHO) will be made on these samples and a recently developed, physically based atmosphere-to-snow transfer model will be used to relate photochemical model estimates of these components to the concentrations of these parameters in the atmosphere and snow. The efficiency of atmosphere-to-snow transfer and the preservation of these components is strongly related to the rate and timing of snow accumulation. This information will be obtained by analyzing the concentration of seasonally dependent species such as hydrogen peroxide, nitric acid and stable isotopes of oxygen. Collection of samples along the US ITASE traverses will allow sampling at a wide variety of locations, reflecting both a number of different depositional environments and covering much of the West Antarctic region.

9814782 *Late Pleistocene Island West Antarctic Ice Sheet Elevations at Mt. Takahe*

Original Start Date:**Sep 01, 1998** Projected Duration:**24 Months**
PI: **Wilch** Institution:**Albion College** State:**Michigan**

This award is for support for a project to establish a detailed record of volcanism at Mt. Takahe volcano in Marie Byrd Land that will provide absolute age and elevation data on inland paleo-ice levels on the West Antarctic ice sheet (WAIS) during the most recent glacial cycle. Previous work at Mt. Takahe documented volcanic deposits located on the lower flanks that were erupted beneath, at, or above the level of the WAIS. These deposits have been dated to between 104,000 and 7,000 years before present and suggest that the inland WAIS was much higher during the last glacial cycle than it is today. The inland paleo-ice level can be used to test conflicting hypotheses about the configuration of the WAIS in late Wisconsin time and the role of WAIS retreat in global sea level rise. Well constrained limits on inland paleo-ice-levels during the past 100,000 years can be compared with global records of climate change in order to assess the relationship between the WAIS and the climate system. Finally, precisely dated paleo-ice- levels can be used as "hard" input data for numerical models of ice sheet dynamics.

9814774 *Collaborative Research: Characterizing the Onset of Ice Stream Flow: A Ground Geophysical Field Program*

Original Start Date:**Sep 15, 2000** Projected Duration:**48 Months**
PI: **Alley** Institution:**PA St U University Park** State:**Pennsylvania**

This award supports a four year project to develop of better understanding the ice streams of the Ross Sea Embayment (A--F) which drain the interior West Antarctic Ice Sheet (WAIS) by rapidly moving vast quantities of ice to the calving front of the Ross Ice Shelf. The project will examine the role of these ice streams

as buffers between the interior ice and the floating ice shelves. The reasons for their fast flow, the factors controlling their current grounding-line-, margin-, and head-positions are crucial to any attempt at modeling the WAIS system and predicting the future of the ice sheet. For the Antarctic ice streams of the Siple Coast, the transition from no-sliding (or all internal deformation) to motion dominated by sliding is defined as the "onset-region". To fully understand (and adequately model) the WAIS, this onset region must be better understood. The lateral margins of the ice streams are also a transition that need better explanation. Hypotheses on controls of the location of the onset region range from the "purely-glaciologic" to the "purely-geologic. Thus, to model the ice sheet accurately, the basal boundary conditions (roughness, wetness, till properties) and a good subglacial geologic map, showing the distribution, thickness, and properties of the sedimentary basins, are required. These parameters can be estimated from seismic, radar, and other geophysical methods. The transition region of ice stream D will be studied in detail with this coupled geophysical experiment. In addition, selected other locations on ice streams C & D will be made, to compare and contrast conditions with the main site on ice stream D. Site-selection for the main camp will be based on existing radar, GPS, and satellite data as well as input from the modeling community.

9814676 *Snow and Firn Microstructure and Transport Properties: U. S. ITASE*

Original Start Date:**Jul 01, 1999** Projected Duration:**36 Months**
PI: **Albert** Institution:**USACRREL** State:**New Hampshire**

This award supports a project to measure snow and firn bulk properties and microstructure along the route of the U.S. International Trans-Antarctic Scientific Expedition (US ITASE) traverses in West Antarctica. These parameters are important because they control the air-snow-firn transport processes and thus the manner in which heat, vapor, and chemical species in air are incorporated into snow and polar firn. The objectives of the project are to obtain field measurements of near-surface (down to 2 meters) snow and firn properties, which include surface roughness, permeability, density, grain size, surface-to-volume ratio, and tortuosity. In addition microstructural measurements and measurements of the above properties will be measured in firn cores down to 20 meters back in the laboratory. These measurements will be used in a transport model to elucidate the nature of the air-snow-firn exchange and firnification process at the various sites along the U.S. ITASE traverse. Since many of the snow and firn properties also affect the interaction of radiation in different parts of the electromagnetic spectrum, these measurements will provide valuable ground truth to those efforts using remote sensing to map the spatial variations of snow, firn and ice properties.

9814574 *Radar Studies of Internal Stratigraphy and Bedrock Topography along the US ITASE Traverse*

Original Start Date:**Apr 01, 1999** Projected Duration:**60 Months**
PI: **Jacobel** Institution:**Saint Olaf College** State:**Minnesota**

This award supports a program of radar studies of internal stratigraphy and bedrock topography along the traverses for the U.S. component of the International Trans-Antarctic Scientific Expedition (US ITASE). The radar will provide information immediately available in the field on ice thickness and internal layer structure to help in the selection of core sites as the traverse proceeds. These data will also be useful in siting deeper millennial scale cores planned at less frequent intervals along the traverse, and in the selection of the location for the deep inland core planned for the future. In addition to continuous coverage along the traverse route, more detailed studies on a grid surrounding each of the core locations will be made to better characterize accumulation and bedrock topography in each area. This proposal is complimentary to the one submitted by the Cold Regions Research and Engineering Laboratory (CRREL), which proposes a high frequency radar to examine the shallower portion of the record down to approximately 60 meters, including the presence of near-surface crevasses. The radar proposed herein is most sensitive at depths below 60 meters and can depict deep bedrock and internal layers to a substantial fraction of the ice thickness.

9814550 *An Archive and Data Distribution System for Glaciological and Cryospheric System Data from the U.S. Antarctic Program: The Antarctic Glaciological Data Center (AGDC)*

Original Start Date:**Apr 01, 1999** Projected Duration:**60 Months**
PI: **Scharfen** Institution:**U of Colorado Boulder** State:**Colorado**

This award supports the establishment of an archive and data distribution system for glaciological and cryospheric data from the U.S. Antarctic Program (USAP). The archive would create a permanent record for upcoming and past field data and would ensure the availability of older data as programs from previous years come to an end or as P.I.s retire. The Antarctic Glaciological Data Center (AGDC) would be modeled on the current Arctic System Science (ARCSS) data management program at NSIDC, which has been a demonstrated success over the last eight years, and would be a logical extension of NSIDC's role as the U.S. Antarctic Data Coordination Center (ADCC), which provides data set information on the spectrum of USAP research activities. The presence of a data center removes the burden of archiving and distributing data from P.I.s- a burden they retain under the currently-funded ADCC. A data protocol would be developed in

concert with key USAP inititatives like the West Antarctic Ice Sheet (WAIS) program and the U.S. component of the International Trans-Antarctic Scientific Expedition (US ITASE) to ensure eventual broad access to their data, while including an appropriate period during which P.I.s would have exclusive use of the data. Examples of the types of data that would be collected and archived include physical and geochemical data from ice cores and snow pits, ice surface elevations, internal layer records, ice thickness and bedrock topography from radar profiles, snow accumulation, grain-size, ablbedo, surface and 10-meter snow temperatures, ice velocity measurements from remote sensing imagery, field survey data and well-characterized digital seismic and radar profile data. The fundamental purpose of the proposed effort is to provide a simple, coordinated, and appropriate means of facilitating the broadest possible utilization of glaciological and related data collected by the USAP.

9814485 *West Antarctic Ice Sheet Surface Melting: Recognition Controls and Significance*

Original Start Date:**Sep 01, 1999** Projected Duration:**36 Months**
PI: **Alley** Institution:**PA St U University Park** State:**Pennsylvania**

This award provides support to study the occurrence of melting in the Ross Embayment of West Antarctica, from a physical and historical perspective, using a combination of techniques (snow-pit, ice-core, AWS, and remotely sensed data, and experiments on melt generation). Surface melting on polar ice sheets occurs as temperatures increase above some threshold. Looking at a variety of records of past surface melting events in Antarctica will reveal changes in the occurrence of especially high temperatures. Joint interpretation of melt and other paleothermometers (borehole temperatures, isotopes, etc.) may allow seasonally resolved paleothermometry. Melting on the surface of an ice sheet can be measured in many ways. Space-based microwave sensors record the occurrence of liquid water or refrozen ice layers in the near surface. Automatic Weather Stations (AWS) record the high temperatures that are linked to development of liquid water. Snow-pit and ice-core studies show layers where refreezing of sufficient liquid water has caused a visibly distinct layer to form. These different measures of melt occurrence are not identical, and are presently not calibrated well to each other. This proposed project will enable the determination of how different measures of melting are related to each other. This knowledge will help glaciologists to learn how melting and climate have changed and affected Antarctic processes in the past, and how they may change in the future. Special focus will be on the critical Ross Ice Shelf and Siple Dome regions of West Antarctica.

9814428 *Collaborative Research: Initial Examination of the 500,000-year Climate Record at Mt. Moulton, West Antarctica*

Original Start Date:**Jun 01, 1999** Projected Duration:**24 Months**
PI: **Dunbar** Institution:**NM Inst of Mining & Tech** State:**New Mexico**

This award supports a two year project to study a 600 meter thick, horizontally-exposed section of ice with intercalated tephra layers in the summit crater of Mt. Moulton, in West Antarctica. The tephra layers, which have been provisionally dated using the Argon-40/Argon-39 technique, range in age from 15,000 to 480,000 years old and are believed to be from a nearby volcano, Mt. Berlin. The objectives of this research are to revisit the Mt. Moulton blue ice site in order to undertake detailed sampling of the ice section and associated tephra layers. In addition to detailed study of the tephra layers (geochemical analysis and further dating of additional layers), the ice will be examined in order to determine climatic variations in West Antarctica over the last 500,000 years. This study will provide complimentary data for the proposed West Antarctic deep ice core and has the potential to yield a much longer climatic record

9814349 *AMS Radiocarbon Chronology of Glacier Fluctuations in the South Shetland Islands During the Last Glacial/Interglacial Hemicycle:Implications for Global Climate Change*

Original Start Date:**Jan 01, 2000** Projected Duration:**24 Months**
PI: **Hall** Institution:**University of Maine** State:**Maine**

This award supports a two year program to produce a new reconstruction of ice extent, elevation and thickness at the Last Glacial Maximum (LGM) for the South Shetland Islands in the Antarctic Peninsula. One field season on Livingston Island will involve mapping the areal extent and geomorphology of glacial drift and determining the elevation and distribution of trimlines. In addition, ice flow direction will be determined by mapping and measuring the elevation of erosional features and the position of erratic boulders. One of the main goals of this work will be to demonstrate whether or not organic material suitable for radiocarbon dating exists in the South Shetland Islands. If so, the age of the deposits will be determined by measuring the carbon-14 age of plant, algal, and fungal remains preserved at the base of the deposits, as well as incorporated marine shells, seal skin and other organic material that may be found in raised beach deposits. Another goal will be to concentrate on the development of relative sea-level curves from 2-3 key areas to show whether or not construction of such curves for the South Shetland Islands is possible. The new reconstruction of ice extent, elevation and thickness at the Last Glacial Maximum for the South Shetland Islands which will be produced by this work will be useful in studies of ocean circulation and ice dynamics in the vicinity of the Drake Passage. It will also contribute to the production of a deglacial chronology which will afford important

clues about the mechanisms controlling ice retreat in this region of the southern hemisphere.

9980691 *CO2 and Delta 13CO2 in Antarctic Ice Cores*
Original Start Date:**Jun 15, 2000** Projected Duration:**36 Months**
PI: **Wahlen** Institution:**U of Cal SD Scripps Inst** State:**California**

This award is for support for three years of funding to reconstruct the atmospheric carbon dioxide (CO_2) and carbon-13 isotope ($\delta^{13}C$) concentration in ice cores from Antarctica over several climatic periods. Samples from the Holocene, the Last Glacial Maximum (LGM)-Holocene transition and glacial stadial/interstadial episodes will be examined. Samples from the Siple Dome ice core drilled in 1998/99 will be made, in addition to measurements from the Taylor Dome and Vostok ice cores. The major objectives are to investigate the phase relationships between variations in the concentration of atmospheric CO2, its carbon isotope composition, and temperature changes (indicated by $\delta^{18}O$ and δ D of the ice) during deglaciations as well as across rapid climate change events (e.g. Dansgaard-Oeschger events). This will help to determine systematic changes in the global carbon cycle during and between different climatic periods, and to ascertain if the widely spread northern hemisphere temperature stadial/interstadial events produced a global atmospheric carbon dioxide signal. Proven experimental techniques will be used.

9980434 *The Physical Properties of the US ITASE Ice Cores*
Original Start Date:**Jul 15, 2000** Projected Duration:**48 Months**
PI: **Meese** Institution:**USACRREL** State:**New Hampshire**

This award is for support for a project to examine the visual stratigraphy, physical and structural properties of the U.S. ITASE ice cores spanning the last 200 years of snow accumulation in Antarctica. A first priority will be to examine visual stratigraphy to delineate annual layer structure for dating purposes and to determine to as great a depth as possible, accumulation variability over the full length of a stratigraphically dated core. A second objective is to measure and analyze depth-density profiles. The rate of snow and firn densification depends on both the rate at which the snow is deposited and the in situ snow temperature. These data can and will be used to derive average snow accumulation rates for the sites where annual layer structure is difficult to decipher or where stratigraphic analysis fails altogether. A third objective will entail measurements of mean crystal size over the full length of a core. Crystal growth is a strongly temperature dependent process and measurements to be made on ITASE cores will help to bridge a significant data gap that exists in the mean annual temperature range, -31 to -50 degrees centigrade. Additionally, crystal size data can also be used, in conjunction with ice loads based on density profile

measurements, to extract mean accumulation rates for these sites where stratigraphic dating of cores proves difficult or impossible to accomplish. This is likely to occur at the lowest accumulation/lowest temperature sites along the ITASE traverse routes

9980379 *The Effects of Impurities on the Flow of Polycrystalline Ice*

Original Start Date:**Jun 01, 2000** Projected Duration:**36 Months**
PI: **Baker** Institution:**Dartmouth College** State:**New Hampshire**

This award is for support for three years of funding to study the effects of impurities on the flow of poly- crystalline ice. It has been known for thirty years that both hydrofluoric acid (HF) and hydrochloric acid (HCl) dramatically decrease the strength of ice and recent work by the author's group has shown that sulfuric acid (H2SO4) produces a similar reduction in strength. However, these data are for single crystals at strain rates and stresses that far exceed those found in glaciers and ice sheets, and often at concentrations that far exceed those in natural ice. Therefore, it is not known how impurities found in nature affect the flow of polycrystalline ice at slow strain rates. In this research, the effects of nitric acid and sulfuric acid (which are naturally occurring impurities in ice) on the microstructure (dislocation structure, grain boundary structure and location of the acids) and creep of polycrystalline ice (at a range of temperatures and stresses) will be determined. The ice's response to creep deformation will be studied using a combination of x-ray topography, optical microscopy and scanning electron microscopy. X-ray microanalysis in an environmental scanning electron microscope will be used to study the location of impurities. The structure and creep behavior of the acid-doped ice will be compared with those of both high-purity laboratory-grown ice and ice from Byrd Station, Antarctica. The end-result of this project will be to elucidate the effects of naturally-occurring acid impurities on the mechanical properties of polycrystalline ice under conditions relevant to the deformation of glaciers and ice sheets, including and understanding of how impurities affect the underlying deformation mechanisms.

9980364 *Diatoms and Cosmogenic Isotopes as Tracers of West Antarctic Ice Sheet History and Processes*

Original Start Date:**Jun 15, 2000** Projected Duration:**36 Months**
PI: **Scherer** Institution:**Northern Illinois Univ** State:**Illinois**

This award provides support for three years for analysis of sediments from beneath current and past grounded ice of the West Antarctic ice sheet. Diatoms and ^{10}Be will be used not only for evidence of past deglacial conditions, but also as sedimentary tracers of microstratigraphic variability in piston cores recovered

by Caltech glaciologists from beneath ice streams B, C and D, and inter-stream ridges. Similar analyses will be performed on sediment cores recovered from beneath the southern Ross Ice Shelf, and the southern Ross Sea near the ice front. Diatoms make excellent sedimentary tracers because, unlike most sedimentary particles, they have known initial conditions (original size, shape, approximate age, and environment of origin). The current study includes quantitative analysis of comminution of Ross Sea diatoms, from laboratory studies, using the ring-shear device developed by Iverson et al. (1998). Preliminary analyses suggest distinctive patterns of diatom breakage that could lead to guidelines for estimating load and shearing of marine diamictons, which may have important implications for interpreting past ice sheet configurations.

9909968 *Developing a 480,000 Year Climate Record for West Antarctica*

Original Start Date:**Apr 01, 2000** Projected Duration:**24 Months**
PI: **White** Institution:**U of Colorado Boulder** State:**Colorado**

This award is for support for two years of funding to develop a 480,000 year climate record for West Antarctica using samples obtained from a 600 meter "horizontal ice core" from the Mt. Moulton blue ice field. Continuous analyses of the deuterium/hydrogen (D/H) ratio of ice (δD_{ice}) and detailed analyses of the elemental/isotopic composition of trapped gases along the Mt. Moulton horizontal ice core will be made to confirm the continuous nature of the record, by comparison with the continuous Vostok ice core record, which spans the last 423 kyr. Once the continuous nature of the record has been confirmed, these results will be correlated with similar records from other Antarctic and Greenland ice cores. In addition, the radiometerically dated tephra layers from Mt. Moulton can then be transferred to other ice cores (namely Vostok) via the gas records (methane (CH_4) and oxygen isotope ($\delta^{18}O$) of paleoatmospheric O2) to improve the current ice core age models for these cores. Results from this study will be very useful in deciphering the recently published Taylor Dome δD_{ice} record in the context of the continent-wide climate history of Antarctica. The Moulton climate records will also be correlated with similar records from the Siple Dome and inland WAIS deep ice core sites when they become available.

9909778 *Retreat History of the West Antarctic Ice Sheet, Marie Byrd Land*

Original Start Date:**Jul 01, 2000** Projected Duration:**24 Months**
PI: **Stone** Institution:**U of Washington** State:**Washington**

This award is for support for two years of funding to reconstruct the retreat history of the West Antarctic ice sheet along a flowline through the Ford Ranges

in Marie Byrd Land, from the last glacial maximum to present. The ice surface elevation history of the region will be reconstructed by cosmogenic isotope exposure dating of moraine boulders and ice-abraded bedrock surfaces in the Clark, Allegheny and Sarnoff Mountains. Altitude transects will date the thinning of the ice sheet at each of these three sites, where the present ice surface stands at ~1200 m, ~800 m and 200-400 m respectively. This research will produce a deglaciation chronology for Marie Byrd Land capable of resolving competing models of ice sheet retreat and will provide a data set for testing numerical models of the West Antarctic ice sheet through the glacial cycle. In addition, the results will help constrain the past ice load in West Antarctica and therefore help to predict the effect of glacioisostatic motion on geodetic surveys being carried out in the region.

9909518 *Collaborative Research:History and Evolution of the Siple Coast Ice Stream Systems as Recorded by Former Shear-Margin Scars*

Original Start Date:**May 15, 2000** Projected Duration:**36 Months**
PI: **Raymond** Institution:**U of Washington** State:**Washington**

This award provides support for three years of funding to study the scar-like features that are well-known from the Siple Coast ice stream system in West Antarctica. The objective of the proposed field work is to identify the nature of several as yet unvisited scars, and to further characterize previously-identified margin scars that are poorly dated. Advanced Very High Resolution Radiometer (AVHRR) and Radarsat image data will be used to locate and map the features, and place them in a regional context. The study seeks to describe the recent history of the Siple Coast glaciers and investigate the causes of their changes in configuration. The main investigative tools will be low-frequency RES and high-frequency ground penetrating radar (GPR) profiles to image internal layers and measure depths to buried crevasses or disrupted layering. This, coupled with accumulation rates determined from shallow ice cores, will provide "shutdown" ages for the margin features. The field data will provide input parameters for simple models of ice flow for margins and inter-ice stream ridges during active shearing and after shutdown. This modeling will estimate the initial elevation of a scar at the time of shut down and the corresponding ice stream elevation at that time.

9909484 *Firn Accumulation Processes in Taylor Dome, Vostok and Siple Dome Ice Using Cosmogenic 14 C and 10Be as Tracers*

Original Start Date:**Apr 01, 2000** Projected Duration:**36 Months**
PI: **Lal** Institution:**U of Cal SD Scripps Inst** State:**California**

This award is for support for three years of funding to develop a history of snow accumulation and physical processes occurring in the upper layers of ice deposited at several sites in Antarctica, using cosmogenic in-situ Carbon-14 (^{14}C) and cosmogenic Beryllium-10 (^{10}Be) as radiotracers. The proposed research emerges from recent studies of cosmogenic in-situ ^{14}C in GISP2 Holocene and several Antarctic ice samples, which revealed marked differences in the 14C concentrations in the samples, compared to the theoretically expected values. The GISP2 samples have about the expected amount of ^{14}C but the Antarctic samples are deficient by 30-50% or more. These results suggest that in slowly accumulating ice samples (such as occur in Antarctica), the cosmic ray implanted ^{14}C is somehow partially lost, but quantitatively preserved in samples from areas of high accumulation. These results suggest that after deposition of the cosmogenic ^{14}C, its concentration is decreased in firn due to processes such as recrystallization, sublimation/evaporation and redeposition. In order to quantify these processes, the atmospheric cosmogenic ^{10}Be in ice samples will also be measured. Since ^{10}Be and ^{14}C have different responses to the firnification processes, their simultaneous study can help to elucidate the nature and importance of these processes. Samples from Taylor Dome, Vostok and Siple Dome will all be studied.

9909474 *Developing a 480,000 Year Climate Record for West Antarctica*

Original Start Date:**Apr 01, 2000** Projected Duration:**24 Months**
PI: **Sowers** Institution:**PA St U University Park**
State:**Pennsylvania**

This award is for support for two years of funding to develop a 480,000 year climate record for West Antarctica using samples obtained from a 600 meter "horizontal ice core" from the Mt. Moulton blue ice field. Continuous analyses of the deuterium/hydrogen (D/H) ratio of ice (dDice) and detailed analyses of the elemental/isotopic composition of trapped gases along the Mt. Moulton horizontal ice core will be made to confirm the continuous nature of the record, by comparison with the continuous Vostok ice core record, which spans the last 423 kyr. Once the continuous nature of the record has been confirmed, these results will be correlated with similar records from other Antarctic and Greenland ice cores. In addition, the radiometerically dated tephra layers from Mt. Moulton can then be transferred to other ice cores (namely Vostok) via the gas records (methane (CH4) and oxygen isotope (d18O) of paleoatmospheric O2) to improve the current ice core age models for these cores. Results from this study will be very useful in deciphering the recently published Taylor Dome dDice record in the context of the continent-wide climate history of Antarctica. The Moulton climate records will also be correlated with similar records from the Siple Dome and inland WAIS deep ice core sites when they become available.

9909469 *Collaborative Research: History and Evolution of the Siple Coast Ice Stream System as Recorded by Former Shear-Margin Scars*

Original Start Date:**May 15, 2000** Projected Duration:**36 Months**
PI: **Scambos** Institution:**U of Colorado Boulder** State:**Colorado**

This award provides support for three years of funding to study the scar-like features that are well-known from the Siple Coast ice stream system in West Antarctica. The objective of the proposed field work is to identify the nature of several as yet unvisited scars, and to further characterize previously-identified margin scars that are poorly dated. Advanced Very High Resolution Radiometer (AVHRR) and Radarsat image data will be used to locate and map the features, and place them in a regional context. The study seeks to describe the recent history of the Siple Coast glaciers and investigate the causes of their changes in configuration. The main investigative tools will be low-frequency RES and high-frequency ground penetrating radar (GPR) profiles to image internal layers and measure depths to buried crevasses or disrupted layering. This, coupled with accumulation rates determined from shallow ice cores, will provide "shutdown" ages for the margin features. The field data will provide input parameters for simple models of ice flow for margins and inter-ice stream ridges during active shearing and after shutdown. This modeling will estimate the initial elevation of a scar at the time of shut down and the corresponding ice stream elevation at that time.

9909384 *Collaborative Research: Accretion of Interplanetary Dust: A New Record From 3HE in Polar Ice Cores*

Original Start Date:**Jan 15, 2000** Projected Duration:**24 Months**
PI: **Brook** Institution:**Washington State Univ** State:**Washington**

This award provides support for two years of funding to construct a new record of interplanetary dust accretion, using Helium-3 (^{3}He) measurements in polar ice core dust. The objective is to test the hypothesis that the earth's 100,000 year, glacial-interglacial climate cycle, a major mode of paleoclimate variability, is caused by variations in the amount of extraterrestrial dust surrounding the earth. Previous work has shown that measurements of extraterrestrial ^{3}He in ice samples are accurate, reproducible, and well within analytical capabilities. Virtually all (> 98%) of the ^{3}He in dust sample from Greenland and Antarctic ice cores is extraterrestrial, based on high ^{3}He /^{4}He ratios and total He budgets. The inferred extraterrestrial ^{3}He flux, from measurements in recently deposited ice, agrees well with estimates based on other methods. The specific objective of the proposed work is to compare variations in ^{3}He flux to both climate variations and predicted variations in extraterrestrial flux based from models of extraterrestrial

dust distribution in the solar system. Because this is a new approach, optimal sample size requirements, size distribution, and statistics of ^{3}He -bearing interplanetary dust particles (IDP's) in ice cores will also be determined. This information will be important for models of 3He accretion and acquisition by IDP's.

9909104 *Deglacial Chronology of the Northern Scott Coast from Relative Sea-Level Curves*

Original Start Date:**Sep 01, 2000** Projected Duration:**36 Months**
PI: **Hall** Institution:**University of Maine** State:**Maine**

This award provides support for three years for a project to develop a radiocarbon chronology for recession of grounded ice from the northwestern Ross Sea Embayment (northern Scott Coast) since the Last Glacial Maximum (LGM). A key unresolved question in Antarctic glaciology concerns the stability of the marine-based West Antarctic ice sheet (WAIS). One way to gain insight into present and future stability is to examine its past behavior. In particular, the timing of deglaciation from the LGM position on the continental shelf is critical for isolating the mechanisms (sea level, climate, ocean temperature, and internal dynamics) that control WAIS dynamics. The northern Scott Coast was likely the first area to become free of grounded ice and hence is critical for isolating triggering mechanisms. Initial retreat from the Ross Sea Embayment was thought to have begun as early as 17,000 years ago; corresponding to the rise in sea level see in the Barbados coral record. In contrast, recent glacial geologic mapping and relative sea-level work from the southern Scott Coast suggests that deglaciation of the Ross Sea Embayment was a Holocene event, with southward grounding-line migration past Ross Island shortly before 6500 14C yr. B.P. This chronology suggests that rising sea level could not have driven grounding-line retreat to the Siple Coast, because deglacial sea-level rise essentially was accomplished by mid-Holocene. One deficiency in the southern Scott Coast work is that it cannot differentiate among the possible triggering mechanisms that initiated retreat because it is 450 km from the LGM grounding-line position. In this project, relative sea level (RSL) curves will be constructed on a transect along the northern Scott Coast from accelerator mass spectrometer 14C dates of seal skin and shells within raised beaches. These curves will provide information concerning the timing of the uploading of grounded ice from the northwestern Ross Sea Embayment. This study should help to evaluate those factors which could have triggered deglaciation and hence controlled the extent of the West Antarctic ice sheet (WAIS).

9904295 *Stable Isotope Studies at West Antarctic ITASE Sites*

Original Start Date:**Mar 01, 1999** Projected Duration:**60 Months**
PI: **Arkin** Institution:**U of MD College Park** State:**Maryland**

This collaborative proposal supports a project to perform stable isotope analyses of samples collected along the International Trans-Antarctic Scientific Expedition (ITASE) traverses which will begin during the 1999/2000 Antarctic field season. This work will focus on the spatial and temporal distribution of oxygen-18 and deuterium in West Antarctica (where data are particularly sparse) and the calibration of the isotope-climate relationship on a site-by-site basis, using instrumental and remote-sensing temperature histories. Specific objectives of this work which contribute to ITASE are: 1) to obtain detailed oxygen-18, deuterium and deuterium excess and stratigraphic histories in snowpits at most or all of the ITASE coring sites; 2) to provide direct calibration of the isotope-climate relationship at each site through a combination of direct (AWS) and indirect (passive microwave satellite) temperature measurements; 3) to obtain isotope profiles covering the last 200 years; and 4) to use the results to provide 200-year climate histories at high temporal and broad spatial resolution across West Antarctica that will allow testing of proposed relationships among isotopes, moisture source conditions, synoptic scale climatology, and site-specific meteorological parameters, and which will enhance our ability to interpret isotope records from older and deeper Antarctic ice cores.

9904294 *Hydrogen Peroxide, Formaldehyde, and Sub-Annual Snow Accumulation in West Antarctica: Participation in West Antarctic Traverse*

Original Start Date:**Feb 15, 1999** Projected Duration:**60 Months**
PI: **McConnell** Institution:**U of Nevada Desert Res Ins**
State:**Nevada**

This award supports a project to improve understanding of atmospheric photochemistry over West Antarctica, as recorded in snow, firn and ice. Atmospheric and firn sampling will be undertaken as part of the U.S. International Trans-Antarctic Scientific Expedition (US ITASE) traverses. Measurements of hydrogen peroxide (H_2O_2) and formaldehyde (HCHO) will be made on these samples and a recently developed, physically based atmosphere-to-snow transfer model will be used to relate photochemical model estimates of these components to the concentrations of these parameters in the atmosphere and snow. The efficiency of atmosphere-to-snow transfer and the preservation of these components is strongly related to the rate and timing of snow accumulation. This information will be obtained by analyzing the concentration of seasonally dependent species such as hydrogen peroxide, nitric acid and stable isotopes of oxygen. Collection of samples along the US ITASE traverses will allow sampling at a wide variety of locations, reflecting both a number of different depositional environments and covering much of the West Antarctic region.

0096338 *Science Management for the United States Component of the International Trans-Antarctic Expedition*

Original Start Date:**Jul 01, 2000** Projected Duration:**36 Months**
PI: **Mayewski** Institution:**University of Maine** State:**Maine**

9725057 Mayewski This award is for support for a Science Management Office (SMO) for the United States component of the International Trans-Antarctic Scientific Expedition (US ITASE). The broad aim of US ITASE is to develop an understanding of the last 200 years of past West Antarctic climate and environmental change. ITASE is a multidisciplinary program that integrates remote sensing, meteorology, ice coring, surface glaciology and geophysics. In addition to the formation of a science management office, this award supports a series of annual workshops to coordinate the science projects that will be involved in ITASE and the logistics base needed to undertake ground-based sampling in West Antarctica.

0096317 *Collaborative Research: Volcanic Records from the Siple and Taylor Dome Ice Cores, Antarctica*

Original Start Date:**Aug 01, 2000** Projected Duration:**21 Months**
PI: **Zielinski** Institution:**University of Maine** State:**Maine**

9614384 Zielinski 9615167 Dunbar Abstract This award supports a project to characterize the volcanic material in the Siple Dome and Taylor Dome ice cores. The time series of volcanic aerosol and tephra deposition available in high-resolution, bi-polar ice cores is the most reliable means of developing continuous and lengthy records of past volcanic activity and assessing the climatic and environmental impact of global volcanism. The volcanic records from the Siple Dome ice core, initial ice core in the West Antarctica Ice Core Program (WAISCORES), and the Taylor Dome core, recently collected from the Transantarctic Mountains, will provide the Southern Hemisphere component of this record. These results will complement the lengthy GISP2 volcanic record from Greenland. Annual resolution should be available in the Siple Dome core for the Holocene resulting in the longest volcanic record with such resolution from Antarctica. Total length of record thought to be available from the Siple Dome core is 80,000 years whereas that for the Taylor Dome core is probably over 100,000 years. Although temporal resolution will be much coarser in the glacial portion of the Siple Dome core and in much of the Taylor Dome core, correlations and comparisons of the volcanic records from those cores with those from the GISP2 core are still possible. Evaluation of the timing of the volcanic signals in relationship to the record of changing climatic conditions available in these ice cores provides critical information on the climate forcing capabilities of global volcanism on decadal to century time scales through the Holocene. The key to developing a reliable chronology of past volcanism from the Siple Dome core is

the simultaneous and continuous measurement of SO_4^{2-}, a direct measure of the volcanic H_2SO_4 produced from the eruption, and the search for tephra in the same subsamples over the entire length of the core. The glaciochemical record will be available through other investigators in the Siple Dome project. The glaciochemical record for the Taylor Dome core is presently available. Locating tephra and identifying the source of the volcanic glass through both optical microscope and microbeam (both electron and ion microprobes) analyses will verify the source of the chemical signal and help differentiate between equatorial and local eruptions. Comparisons with the GISP2 volcanic record will assist in achieving this goal. This multiparameter approach to deciphering the volcanic record will improve on our understanding of the influence of volcanism on climate both interhemispherically and intrahemispherically. The correlation of tephra found in these cores with that found in marine sediments and in the terrestrial record will expand on the chronology of global volcanism and improve the correlation among ice core, marine, and terrestrial proxy climatic records. Visible tephra layers that should exist in the Siple Dome core and do exist in the Taylor Dome core will provide additional absolute time lines for possible correlations between the two cores, among previously collected Antarctica ice cores and with tephra studies in blue ice areas of Western Antarctica and the Transantarctic Mountains.

0096302 *Control of Ice-Till Interactions on Evolution and Stability of Ice Streams and Ice Sheets*

Original Start Date: **Jul01,2000** Projected Duration:
PI: **Tulaczyk** Institution:**U of Cal Santa Cruz** State:**California**

This award provides support for a three-year project to study the control of ice-till interactions on the evolution and stability of ice streams and ice sheets. As part of this project, an extensively tested numerical ice stream model will be merged with a new physical framework for treatment of sub-ice stream processes which control the commencement, evolution, and cessation of ice streaming. This framework, called the undrained-plastic -bed (UPB) model, is based on observations of physical condition beneath Ice Stream B, in West Antarctica. This model will be applied to the drainage basins of Ice Streams B and E to test four important hypotheses: 1) that the model can reproduce the main features of the observed ice stream velocity distribution; 2) that the model may produce a relatively abrupt ice stream stoppage; 3) that a significant imbalance of the West Antarctic ice streams may be caused in the near future by internal instabilities and 4) that imbalance of the ice streams may also be caused by either an increase in ice surface temperature or a doubling of snow accumulation rates. The proposed research will provide an important new advancement in the science of ice sheet modeling, while yielding predictions on ice stream behavior that may become testable in the near future.

0096299 *US ITASE Glaciochemistry*

Original Start Date:**Jul 01, 2000** Projected Duration:**48 Months**
PI: **Mayewski** Institution:**University of Maine** State:**Maine**

This award provides funding for five years of support to participate in the U.S. component of the International Trans-Antarctic Scientific Expedition (US ITASE). US ITASE is made up of four major research disciplines: meteorology, remote sensing, ice coring, and surface glaciology and geophysics. US ITASE hopes to answer questions about the mass balance over West Antarctica and the influence of major atmospheric circulation systems and oceanic circulation on the moisture flux over West Antarctica. In addition, questions about the controls on climate variations over seasonal, inter-annual, decadal and centennial scales will be addressed. Other factors to be examined by US ITASE relate to the impact of anthropogenic activity on the climate and atmospheric chemistry of West Antarctica as well as the variations in biogeochemical cycling of sulfur and nitrogen compounds over the last 200 years. This project will perform analyses of the glaciochemistry (i.e. major anions and cations) of shallow and intermediate depth ice cores collected on the US ITASE traverses. The ionic composition of polar ice cores provides not only a stratigraphic tool for relative dating but also documents changes in chemical species source emissions and allows characterization of the major atmospheric circulation systems affecting the West Antarctic ice sheet.

0089902 *SGER Proposal: Iceberg drift in the near-shelf environment, Ross Ice Shelf, Antarctica*

Original Start Date:**Sep 01, 2000** Projected Duration:**12 Months**
PI: **MacAyeal** Institution:**University of Chicago** State:**Illinois**

The recent calving of a large iceberg (B15) from the Ross Ice Shelf presents a unique opportunity to measure the processes which control the drift of large tabular icebergs including, wind-driven and thermohaline currents, tides, sea ice, and winds. The calving of such an extraordinarily large iceberg within the logistics reach of the US Antarctic Program, is rare. Thus the calving of B15 offers an exciting opportunity to study iceberg drift, and all of the other aspects of iceberg behavior which are associated with the long-term stability of the Antarctic environment. The extraordinary freshwater volume of large tabular icebergs has in the past been identified as a natural resource of human economic value (e.g., for water poor regions of the earth). Feasibility studies of iceberg towing to water-poor regions have largely been poo-pooed as science fiction. Nevertheless, tabular icebergs commonly travel thousands of miles as a result of natural processes which, if understood, could perhaps be harnessed for human economic and social value. We propose to make direct measurements of the drift of icebergs B15a, B15b and a smaller iceberg (either B16, B17 or B18,

depending on circumstances) to: 1. observationally constrain parameters that will improve the models of iceberg drift, e.g., by determining drag coefficients appropriate to atmospheric and oceanic interactions, including drag induced by sea ice, 2. improve our ability to predict calving events and the subsequent iceberg drift trajectory, 3. compliment ongoing remote sensing study of the iceberg and its behavior 4. measure the progress of the berg(s) toward logistically sensitive areas. The last point reflects the fact that interest in B15's drift over the next year(s) is not restricted to the realm of basic science. It is conceivable that B15 and its progeny (it is now in two pieces and has caused smaller bergs to calve from the Ross Ice Shelf) poses a complication to normal shipping to and from the US's main research and logistics station in Antarctica. While this proposal represents the broad scientific interests of several investigators at several institutions, its focus is narrow. Support is requested for assembly and deployment of instruments to observe the weather conditions and the drift of B15.

0088047 *Mass and Energy Fluxes Through Lake Vostok: Observations and Models*

Original Start Date:**Jun 01, 2001** Projected Duration:**24 Months**
PI: **Bell** Institution:**Columbia University** State:**New York**

This award supports a two year project to address fundamental questions about the mass and energy flux through Lake Vostok, a subglacial lake in East Antarctica, sealed beneath almost 4 kilometers of ice. The project will involve developing lake circulation models, complemented by the analysis of new ice penetrating radar data over the lake and surrounding regions. This project will help to accurately define the regions of melting and freezing within the lake and help to provide an improved estimate of the form of the lake. The combined data analysis and modeling effort will provide a critical framework for developing international plans to sample the waters of Lake Vostok for biota and to recover sediments from Lake Vostok for paleoclimate studies.

0088035 *High Resolution Radar Profiling of the Snow and Ice Stratigraphy beneath the ITASE Traverses, West Antarctic Ice Sheet*

Original Start Date:**Jul 01, 2001** Projected Duration:**24 Months**
PI: **Arcone** Institution:**USACRREL** State:**New Hampshire**

This award supports continued acquisition of high resolution, radar reflection profiles of the snow and ice stratigraphy between core sites planned along traverse routes of the U.S. component of the International Trans-Antarctic Scientific Expedition (U.S.-ITASE). The purpose is to use the profiles to establish the structure and continuity of firn stratigraphic horizons over hundreds of

kilometers and to quantitatively assess topographic and ice movement effects upon snow deposition. Other objectives are to establish the climatic extent that a single site represents and to investigate the cause of firn reflections. The radar will also be used to identify crevasses ahead of the traverse vehicles in order to protect the safety of the scientists and support personnel on the traverse. Collaboration with other ITASE investigators will use the radar horizons as continuous isochronic references fixed by the core dating to calculate historical snow accumulation rates. The primary radar system uses 400-MHz (center frequency) short-pulse antennas, which (with processing) gives the penetration of 50-70 meters. This is the depth which is required to exceed the 200-year deposition horizon along the traverse routes. Profiles at 200 MHz will also be recorded if depths greater than 70 meters are of interest. Processing will be accomplished by data compression (stacking) to reveal long distance stratigraphic deformation, range gain corrections to give proper weight to signal amplitudes, and GPS corrections to adjust the records for the present ice sheet topography. Near surface stratigraphy will allow topographic and ice movement effects to be separated. This work is critical to the success of the U.S.-ITASE program

0087999 *Glacial-Interglacial Variations in $\delta^{17}O$ of O_2 in Ice Cores: Implications for Interactions Between Climate and the Biosphere*

Original Start Date:**Jan 01, 2001** Projected Duration:**36 Months**
PI: **Bender** Institution:**Princeton University** State:**New Jersey**

This award supports a project to continue studies of the triple isotope composition (O-17 and O-18) of oxygen in fossil air trapped in ice cores. This property is of interest because photochemical reactions in the stratosphere induce isotope exchange between oxygen and carbon dioxide that lowers the O-17 of oxygen by the same amount as the O-18 ("mass independent fractionation"). This isotopic tag is anomalous in the sense that other factors influencing the isotopic composition of oxygen change O-17 by 0.5 times as much as they change O-18. Respiration consumes ambient (anomalous) oxygen , and photosynthesis replaces it with oxygen which is normally fractionated. Therefore, the triple isotope composition of oxygen give a measure of the gross rate of photosynthesis on the planet. Preliminary results focussing on the last 60,000 years indicate that the production of the global biosphere during the Last Glacial Maximum was about 90% of that today. Because land production was much less than today, the O-isotope data imply that oceanic gross production was much greater than today. This increase has been attributed to a higher glacial flux of dust (and iron) to the oceans. This project will extend current measurements of the triple isotope composition of oxygen back to 400,000 years in order to derive the curve of the relative rate of photosynthetic oxygen production vs. time. The results, at 1 kyr resolution, will constrain changes in

production associated with glacial maxima, interglacials and glacial terminations; with long interstadial events; and with orbital insolation cycles unaccompanied by large changes in ice volume. This work will lead to a better understanding of ways in which the biosphere responds to and influences climate.

0087776 *Collaborative Research: Deposition of the HFC Degradation Product Trifluoroacetate in Antarctic Snow and Ice*

Original Start Date:**May 15, 2001** Projected Duration:**36 Months**
PI: **McConnell** Institution:**U of Nevada Desert Res Ins**
State:**Nevada**

This award supports a three year project to acquire data on the concentration of trifluoroacetate (TFA) in Antarctic snow. Trifluoroacetate is a highly persistent, atmospheric degradation product of the halogenated ethane derivatives (HCFC, HFC) that have been introduced as environmentally friendly chlorofluorocarbon (CFC) substitutes. However, there is concern that the widespread introduction of HCFC's and HFC's will lead to the accumulation of TFA in aquatic ecosystems. Current data on pre-industrial, background concentration of TFA in meteoric and surface waters, including Antarctic ice, are ambiguous and the impact of anthropogenic TFA on these background concentrations is unclear. Ice core records can provide proxy records of background and anthropogenic TFA deposition. The primary objective of this research is to use ice cores and snow pits at South Pole to develop a temporal record of TFA deposition spanning ~ 1000 years but focused on the past 20 years. The pre-industrial to present record of TFA in near surface snow and ice at South Pole and in West Antarctica will be unique and will lead to a much better understanding of the origin, transport and fate of this contaminant over Antarctica and possibly the globe. In addition, understanding the natural and anthropogenic sources, the regional and long-range movement, and the eventual fate of contaminants is critical to assessing potential impacts on Antarctic ecosystems.

0087731 *Collaborative Research: Deposition of HFC Degradation Product Trifluoroacetate in Antarctic Snow and Ice*

Original Start Date:**May 15, 2001** Projected Duration:**36 Months**
PI: **Miller** Institution:**U of Nevada Reno** State:**Nevada**

This award supports a three year project to acquire data on the concentration of trifluoroacetate (TFA) in Antarctic snow. Trifluoroacetate is a highly persistent, atmospheric degradation product of the halogenated ethane derivatives (HCFC, HFC) that have been introduced as environmentally friendly chlorofluorocarbon (CFC) substitutes. However, there is concern that the widespread introduction of HCFC's and HFC's will lead to the accumulation of TFA in aquatic ecosystems.

Current data on pre-industrial, background concentration of TFA in meteoric and surface waters, including Antarctic ice, are ambiguous and the impact of anthropogenic TFA on these background concentrations is unclear. Ice core records can provide proxy records of background and anthropogenic TFA deposition. The primary objective of this research is to use ice cores and snow pits at South Pole to develop a temporal record of TFA deposition spanning ~ 1000 years but focused on the past 20 years. The pre-industrial to present record of TFA in near surface snow and ice at South Pole and in West Antarctica will be unique and will lead to a much better understanding of the origin, transport and fate of this contaminant over Antarctica and possibly the globe. In addition, understanding the natural and anthropogenic sources, the regional and long-range movement, and the eventual fate of contaminants is critical to assessing potential impacts on Antarctic ecosystems.

0087709 *Chronology of the West Antarctic Ice Sheet: New Evidence from Marie Byrd Land Nunataks*

Original Start Date:**Jun 15, 2001** Projected Duration:**24 Months**
PI: **Kurz** Institution:**Woods Hole Ocean Inst**
State:**Massachusetts**

This award supports a project for a detailed laboratory-based study of glacial moraine boulders collected on the flank of Mt. Waesche, a nunatak in the Executive Committee Range, Marie Byrd Land, West Antarctica. Preliminary work on these samples resulted in measurement of past ice sheet elevations in interior West Antarctica. Funds are requested here to measure exposure ages in the remaining samples from the moraine and adjacent volcanic bedrock. The goal is to use a combination of field observations, surface exposure dating (Helium-3, Neon-21 and Chlorine-36) and Argon-40/Argon-39 dating to constrain past elevations of the West Antarctic ice sheet (WAIS). The initial study demonstrated that higher past ice levels are recorded by moraines, composed of volcanic debris left behind by receding ice, and that Helium-3 and Chlorine-36 surface exposure dating can be used to constrain the timing of past ice high stands. It is expected that these analyses will refine the initial results pertaining to the last deglaciation and provide a unique record of earlier ice sheet elevations. The primary long-term objective is to provide chronological and elevation data of the paleoglaciology of the interior of the WAIS prior to 10 kA. The unique record of surface ice elevations at Mt. Waesche provides key constraints on the behavior of the ice sheet and its response to climate and sea level change. This information will contribute strongly to determining why the WAIS behaved as it did during the last deglaciation and the previous interglacial, and will help efforts to predict how it will change in the future.

0087521 *Borehole Fingerprinting: Vertical Strain, Firn Compaction, and Firn Depth-Age Scales*

Original Start Date:**May 01, 2001** Projected Duration:**24 Months**
PI: **Waddington** Institution:**U of Washington** State:**Washington**

This award supports a two year project to develop a new method for measuring vertical strain rates in polar firn. Vertical strain rate measurements in the firn are important because they can aid in the understanding of the dynamics of firn compaction, a key factor in determining ice age/gas age difference estimates for ice cores. Vertical strain rate measurements also determine ice advection for borehole paleothermometry models, and most importantly can be used to date the shallow sections of ice cores where ambiguities in chemical dating or counting of annual layers hinder dating by traditional methods. In this project a video logging tool will be used to create a unique "optical fingerprint" of variations in the optical properties of the firn with depth, and track the movement and deformation of the features of this fingerprint. Preliminary work at Siple Dome, Antarctica using an improvised logging system shows a series of optically bright and dark zones as the tool transits up or down the hole. Borehole fingerprinting has the potential to improve measurements of vertical strain in firn holes. This project represents a unique opportunity to interface with an existing field program where a borehole vertical strain rate project is already underway. A graduate student will be supported to conduct the work on this project as part of a PhD. dissertation on climate and physical processes in polar firn.

0087439 *Separating Net Accumulation into Precipitation and Sublimation in Firn*

Original Start Date:**Aug 01, 2001** Projected Duration:**24 Months**
PI: **Waddington** Institution:**U of Washington** State:**Washington**

This award supports a project to develop the techniques for separating net accumulation into precipitation and sublimation in polar firn. The project will use existing models for firn ventilation and models for the transfer of chemical species to firn to create an integrated model of vapor and chemical species transport in firn for suites of species that respond differently to water mass loss. This forward model will predict the dependence of geochemistry on water vapor loss. The knowledge gained from these forward models will then be used to solve an inverse problem to predict the amount of water vapor sublimation and redeposition based on profiles of geochemistry in firn. This project is a necessary first step toward inferring precipitation and evaporation in ancient environments, such as are recorded in ice cores. This project will serve as the basis for a Ph.D. dissertation for a student under the direction of the P.I. Determining how to best extract climate information from firn and ultimately ice cores is the major goal of this project.

0087380 *Relating West Antarctic Ice Cores to Climate with Artificial Neural Networks*

Original Start Date:**May 01, 2001** Projected Duration:**36 Months**
PI: **Alley** Institution:**PA St U, University Park**
State:**Pennsylvania**

This award provides three years of support to use a broad, adaptable, multi-parameter approach, using a range of techniques including artificial neural networks to seek the relations between meteorological conditions and the snow pit and ice core records they produce. Multi-parameter, high resolution, ice core data already in hand or now being collected reflect snow accumulation, atmospheric chemistry, isotopic fractionation, and other processes, often with subannual resolution. The West Antarctic sites from which such data are available will be used as starting points for back-trajectory analyses in reanalysis data products to determine the meteorological conditions feeding the data stream. The artificial neural nets will then be used to look for optimal relations between these meteorological conditions and their products. Previous work has demonstrated the value of reanalysis products in determining snow accumulation, of back trajectory analyses in understanding glaciochemistry, and of artificial neural nets in linking meteorological conditions and their products. Preliminary work shows that neural nets are successful in downscaling from reanalysis products to automatic weather station data in West Antarctica, enabling interpolation of site-specific data to improve understanding of recent changes in West Antarctic climate.

0087357 *Measurement and Interpretation of δ13C of Atmospheric Methane from the Law Dome Ice Cores*

Original Start Date:**Jul 01, 2001** Projected Duration:**36 Months**
PI: **White** Institution:**U. of Colorado, Boulder** State:**Colorado**

This award supports a project to examine and compare high resolution methane concentration and isotopic histories during the last millennium from the Law Dome ice core in coastal Antarctica. Atmospheric methane is an important chemical component of both the stratosphere and troposphere, and is a major contributor to the anthropogenic enhancement of the greenhouse effect. Quantifying the budget of methane has proven difficult because of the wide range of sources and locations from which it is emitted. Measurements of the atmospheric concentration and the carbon isotopic composition of methane have enabled a greater understanding of the controls over the modern methane budget. Studies of the methane budget prior to and during industrialization and the emergence of large human populations can help in the understanding of the

controls on this budget. Measurements of the carbon-13:carbon 12 ratio and of the carbon isotopic composition (d 13C) of methane in air from the last millenium trapped in polar ice will be made to aid in understanding of the paleo-methane budget. This is a collaborative effort between the stable isotope laboratory and the University of Colorado and the New Zealand National Institute of Water and Atmospheric Research, the Australian Antarctic program and the NOAA carbon cycle group. The Australian and New Zealand groups will provide the ice and past results of Antarctic firn air measurements and the stable isotope lab will provide expertise on isotopic measurements of very small firn air samples. The carbon cycle group will assist in the calibration of standards and analysis of firn air samples. All groups will participate in the modeling and interpretation of results.

0087273 *A Digital Thermometer to Enhance High Resolution Borehole Paleothermometry at Siple Dome and Beyond: a Unique Opportunity*

Original Start Date:**Apr 01, 2001** Projected Duration:**12 Months**
PI: **Waddington** Institution:**U. of Washington** State:**Washington**

This award supports the development and testing of digital probes for high precision temperature measurements in boreholes in polar ice sheets. These measurements are key to obtaining calibrated paleotemperature records in the polar regions. The current state-of-the-art system is the USGS Polar Borehole Temperature Logging System (PBTS), which uses analog probe technology with the electronic package at the ice sheet surface. Strong winds can disturb the recording electronics, forcing the field team to modify logistics plans to produce high quality data. Probes that transmit digital signals up the cable would not be affected by these surface conditions, improving the efficiency of field operations. This project will adapt a recently-designed digital probe for use with the PBTS system in cold temperatures in polar drilling fluids. These probes will reduce some of the stringent hardware and procedural requirements of the current analog system. These new digital probes will be calibrated alongside the currently used sensors and will be tested at Siple Dome as part of an already-funded program of borehole temperature logging. The final product (in addition to a working borehole temperature logging system with new digital probes) will be a publication in the Journal of Glaciology describing the new probes, the comparisons, and the new research opportunities that digital probes can offer.

0087160 *Continuation of Physical Properties of the Siple Dome Deep Ice Core*

Original Start Date:**Jun 01, 2001** Projected Duration:**36 Months**

PI: **Alley** Institution:**PA St. U., University Park**
State:**Pennsylvania**

This award provides support to continue paleoclimate and ice dynamical studies of the Siple Dome deep ice core and associated shallow cores from West Antarctica, to help understand the history of climate and ice-sheet stability. Visible examination of the ice cores contributes to the required dating of the paleoclimatic records. Because ice-flow corrections for accumulation rates are difficult in deep ice, a new physically based paleoclimatic indicator of temperature or snow accumulation will be developed, based on bubble-size histories and on the physics of firn densification and grain growth. The paleoclimatic reconstruction of summer temperatures will be accomplished through observation and analysis of the rare melt layers in the ice core. Studies of the distribution of climate change in space and time will be continued, focusing on the possibility that a climate oscillation of ~ 1500 years has combined with "noise" from changes in freshwater fluxes to force rapid, large, nearly synchronous, widespread to global changes in the mode of operation of the climate system. Visual and c-axis studies of ice grains in the core will help detect flow disturbances, such as the ones which were seen in the GISP2 ice cores, if they are present in the Siple Dome core. The results of this study should lead to a better understanding of rapid climate change in Antarctica and, through comparison, to other records worldwide. The study should also contribute to knowledge of the flow and stability of the West Antarctic ice sheet.

0087151 *A Sulfate-based Volcanic Record from South Pole Ice Cores*

Original Start Date:**Feb 01, 2001** Projected Duration:**24 Months**
PI: **Cole-Dai** Institution:**South Dakota State Univ** State:**South Dakota**

This award supports a two year project to analyze shallow (~150 m) ice cores from South Pole in order to construct an annually resolved, sulfate-based volcanic record covering the last 1400 years. Two shallow ice cores will be recovered at the South Pole during the 00/01 field season and will be used for this work. Volcanic records from polar ice cores provide valuable information for studies of the connection between volcanism and climate. The new records are expected to be continuous and to cover at least the last 1400 years. The information from these records will verify the volcanic events found in the few existing Antarctic records and resolve discrepancies in the timing and magnitude of major explosive eruptions determined from those earlier records. In order to achieve the objectives of the proposed research, funds are provided to assist with the construction of an analytical laboratory for ice core and environmental chemistry research.

0087144 *Glacial History of Ridge AB, West Antarctica*
Original Start Date:**Aug 01, 2001** Projected Duration:**48 Months**
PI: **Conway** Institution:**U of Washington** State:**Washington**

This award supports the study the glacial history of Ridge AB in West Antarctica using well-established geophysical methods. Our study is motivated by the need to improve under-standing of how the configuration and activity of the West Antarctic drainage system is changing, and how this affects the stability of the ice sheet. Ridge AB has been chosen for several reasons: 1) previous studies of inter-stream ridges in West Antarctica have revealed much information about the history of the surrounding ice streams. There is an "information-hole" in the southern sector of the ice sheet; we are optimistic that our study of Ridge AB will reveal new information about recent changes in the configuration and activity of Ice Streams A and B; 2) geologic evidence from Reedy Glacier indicates that ice in the vicinity of Ridge AB was ~700 m thicker during the last glacial maximum. This helps constrain the magnitude of thinning that has occurred through the Holocene, and opens the possibility of linking the history of the West Antarctic Ice Sheet to the geologic record in the Trans-Antarctic Mountains. Our approach is to first map spatial variations of internal layering, buried crevasses, surface velocity, and accumulation rate. The main investigative tools are: high and low-frequency radar systems, GPS surveying methods, and short (20 m) firn cores. The diagnostic measurements will then be examined with ice flow models to infer the glacial history of Ridge AB and the surrounding ice streams. The history will be interpreted in context of the histories that are emerging from the other inter-ice stream ridges, as well as the geologic evidence from Reedy and other outlet glaciers in the Trans-Antarctic Mountains. Our overall goal is to improve understanding of the evolution of the WAIS drainage system.

0086997 *Margin Migration Rates and Margin Dynamics of the Siple Coast Ice Streams*
Original Start Date:**Aug 01, 2001** Projected Duration:**24 Months**
PI: **Truffer** Institution:**U of Alaska Fairbanks** State:**Alaska**

This award supports a two year project to investigate the dynamics of the marginal zone of the Siple Coast ice streams using existing velocity and temperature profiles. The flow and stress fields will be modeled using finite element methods and a thermo-mechanical model will be used to investigate the coupling of the flow and temperature fields. Direct comparison of these models with the observed velocity profiles will lead to estimates of the structure of the margins and the softening of the marginal ice. The distribution of basal and marginal shear stress will be investigated, leading to an estimate of the relative roles of the bed and the margins in the overall force balance of the ice streams.

0086645 *SGER Proposal:Glaciological change in the McMurdo Dry Valleys, Antarctica*

Original Start Date:**Sep 01, 2000** Projected Duration:**12 Months**
PI: **Fountain** Institution:**Portland State University** State:**Oregon**

This award supports a Small Grant for Exploratory Research (SGER) to study glaciological change in the McMurdo Dry Valleys, Antarctica under the category of "application of new expertise or new approaches to established research topics". The purpose of the project is to assess the application of classified imagery to the study of the magnitude and rate of change of glacier extent and lake area as an indicator of climate change. Because the rate of change of both glacier extent and lake area is small compared to the resolution of unclassified imagery, the increased resolution of classified imagery is clearly needed. Access to classified imagery with 1 meter or better resolution will provide a baseline measurement against which future changes can be compared. Maximum use will be made of archived imagery but if necessary, one request will be made for new imagery to supplement the existing archive. This work will support on-going field measurements which are part of the Long-Term Ecological Research (LTER) site in the McMurdo Dry Valleys but which are limited by logistic constraints to only a few measurements during limited times of the year. If successful, the information gained in this project will enable researchers to better direct their efforts to identify the important physical processes controlling the changes in the valleys. The information acquired in conducting this project will be made available to the public, using appropriate security procedures to declassify the data. The "exploratory" and "high risk" nature of the proposed work and its "potential" to make an important "impact" on the field of Antarctic glacier studies are all reasons that this work is appropriate to support as an SGER.

0003873 *Collaborative Research: West Antarctic Ice-Sheet and Alpine Glacier Variability During the Latest Pleistocene: An Integrated Radar, Drilling and Exposure-Age Study in McMurdo Sound*

Original Start Date:**Jul 01, 2001** Projected Duration:**12 Months**
PI: **Kurz** Institution:**Woods Hole Ocean Inst**
State:**Massachusetts**

This award supports a one year lab-based study which will allow a detailed calibration between ground-penetrating radar (GPR) data and existing drilled sediment sequences from Lower Taylor Valley, which will improve the lithostratigraphy in the region. In addition, exposure-age dating of existing samples from the Hjorth Hill locality in Taylor Valley will also be carried out in

order to test the multiple drift-sheet interpretation of the GPR data. All of the goals described in the revised scope of work are consistent with the goal of the original proposal, which was to resolve multiple WAIS glaciations and regional climate change. This work is complementary to studies of the variability of the West Antarctic ice sheet (WAIS) and will help to improve resolution of alpine and piedmont glacier variability during the latest Pleistocene.

0003792 *Collaborative Research: West Antarctic Ice-Sheet and Alpine Glacier Variability During the Latest Pleistocene: An Integrated Radar, Drilling and Exposure-Age Study in McMurdo Sound*

Original Start Date:**Jul 01, 2001** Projected Duration:**12 Months**
PI: **Prentice** Institution:**U of New Hampshire** State:**New Hampshire**

This award supports a one year lab-based study which will allow a detailed calibration between ground-penetrating radar (GPR) data and existing drilled sediment sequences from Lower Taylor Valley, which will improve the lithostratigraphy in the region. In addition, exposure-age dating of existing samples from the Hjorth Hill locality in Taylor Valley will also be carried out in order to test the multiple drift-sheet interpretation of the GPR data. All of the goals described in the revised scope of work are consistent with the goal of the original proposal, which was to resolve multiple WAIS glaciations and regional climate change. This work is complementary to studies of the variability of the West Antarctic ice sheet (WAIS) and will help to improve resolution of alpine and piedmont glacier variability during the latest Pleistocene.

0003616 *Studying Byrd Glacier as a Rock-Floored Ice Stream Ending as a Calving Ice Shelf: Phase I*

Original Start Date:**Feb 15, 2001** Projected Duration:**12 Months**
PI: **Hughes** Institution:**University of Maine** State:**Maine**

This award supports a one-year study of the floating part of Byrd Glacier, from its grounding line located halfway up a fjord through the Transantarctic Mountains to the end of its lateral rift zone on the Ross Ice Shelf beyond the fjord. Over this l00 km distance, the side boundary changes from rigid between the fjord sidewalls, to nearly free in the lateral rift zone, to deforming when the rifts are healed and Bryd Glacier becomes fully coupled to the Ross Ice Shelf. The stress field for these changing conditions will be calculated a using a gridpoint finite-element model for the Ross Ice Shelf (Thomas and MacAyeal, l982) and a flowband finite-difference model for smooth transitions from sheet flow to stream flow to shelf

flow (Hughes, l998). Results of the two modeling approaches will be compared, using existing ice elevation and velocity data obtained from aerial photogrammetry, our unpublished surface mass balance data, and new velocity data obtained from Landsat imagery by the U. S. Geological Survey. This study will train one graduate student at the Masters level.

0003490 *Collaborative Research: Discharge Variability of Ross Ice Streams Over the Last Millenium, Deduced by Numerical Simulation of Flow Features in the Ross Ice Shelf*

Original Start Date:**Feb 01, 2001** Projected Duration:**36 Months**
PI: **Fahnestock** Institution:**U of MD College Park**
State:**Maryland**

This award supports the investigation of the discharge variability of Ross Ice Streams over the last millenium, using a combination of numerical simulation and satellite remote sensing of flow features on the Ross Ice Shelf. The proposed collaborative research will use the Ross Ice Shelf record of flow variability to deduce variations in ice stream discharge over the last 1000 years. Changes in ice stream discharge disrupt flow of the ice shelf, in both profound and subtle ways, distorting flow features and changing creavasse patterns. The result is an integrated record of many changes over the lifetime of the ice within the shelf. Interpretations of flow-trace and crevasse geometry already made by Fahnestock and others will be used as a template for the design of numerical modeling experiments. The primary objectives are to verify the imagery-derived history and to quantify the volume flux implied by that history. The proposed research will improve existing concepts of ice stream discharge variability and will produce new data sets, both of which will be of use to the Antarctic glaciology community. Landsat-7 imagery will be used to measure velocity in areas of particular interest where existing data are inadequate. MODIS data, which has better radiometric and spatial resolution will be used to improve feature mapping on the ice shelf in sensitive areas.

0000515 *Workshop Support: West Antarctic Ice Sheet (WAIS) Workshop Support in Sterling, Virginia, September 27-30, 2000*

Original Start Date:**Jun 15, 2000** Projected Duration:**36 Months**
PI: **Bindschadler** Institution:**NASA-Goddard Space Flight**
State:**Maryland**

This award is for support for continuation of the West Antarctic Ice Sheet (WAIS) Program workshops that have been run by Dr. Bob Bindschalder at NASA/GSFC for the last several years. The WAIS program has successfully focused a broad

cross-section of the Antarctic research community on two urgent global issues: future sea level and rapid climate changes. WAIS is multidisciplinary and the requested support is to foster continued cross-disciplinary interaction. WAIS workshops began in 1990-first to formulate the objectives of WAIS and, beginning in 1992, to exchange and present scientific findings in a forum where cross-disciplinary scientific discourse was promoted and progress toward WAIS goals could be annually assessed. The funds provided here are to support future WAIS workshops by assisting in the notification, organization and execution of the annual WAIS workshops for the next three years. In addition, the funds will be used to further enhance these workshops by offering travel stipends to attract new participants deemed by the WAIS working group to be key persons in further enhancing the WAIS program.

0196441 *Mass Balance and Accumulation Rate Along US ITASE Routes*

Original Start Date:**Sep 01, 2000** Projected Duration:**12 Months**
PI: **Hamilton** Institution: **University of Maine** State:**Maine**

This award provides support for five years of funding to determine the mass balance and accumulation rate of ice along the traverse routes of the U.S. International Trans-Antarctic Scientific Expedition (US ITASE) program. The rate of ice sheet thickening or thinning will be measured along flow lines, along ice divides and along elevation contours in West Antarctica using a method which measures the vertical velocities of markers buried in subsurface ice. This method uses the Global Positioning System (GPS) and surveying techniques to determine the precise location of these markers. Vertical velocities so obtained are compared with long-term rates of snow accumulation and the difference in the two is a measure of ice sheet thickness change. A series of recording instruments will be installed to provide continuous records of firn densification and snow surface elevation change. These instruments will be deployed at selected sites to link transient changes in snow surface elevation, as measured by altimeters, to long-term rates of ice thickness change. Ice motion at drill sites, upglacier topography and upglacier gradients in accumulation rate will be measured and used to calculate ice flow-induced accumulation rate variations and remove them from the ice core records. This work will provide the capability to deduce true past climatic variations in accumulation rate from the US ITASE ice core records.

0196346 *Biogenic Sulfur in the Siple Dome Ice Core*

Original Start Date:**Dec 31, 2000** Projected Duration:**12 Months**
PI: **Saltzman** Institution:**U of Cal Irvine** State:**California**

This award is for support for four years of funding for a program of biogenic sulfur measurements on the Siple Dome ice core. Biogenic sulfur is a major aerosol-forming constituent of the atmosphere and has potentially important links to the earth's radiation budget. Previous work on the Vostok ice core has demonstrated a remarkable climate-related variability in biogenic sulfur, suggesting that the sulfur cycle may act to stabilize climate (keep the glacial atmosphere cool and the interglacial atmosphere warm) in the Southern Hemisphere. In this study, methane-sulfonate (MSA) will be measured on the Siple Dome ice core as part of the West Antarctic ice sheet program (WAIS). Siple Dome is located in a region which is strongly impacted by the incursion of marine air onto the Antarctic plateau. Because of its proximity to the coast and meteorological setting, it is expected that variability in high-latitude marine biogenic sulfur emissions should dominate the MSA record at this site. In addition to the deep ice core record, samples from shallow cores will also be analyzed to provide information about regional variability and decadal-to-centennial scale variability in the deposition of sulfur-containing aerosols from high latitude source regions over the past 200 years.

0196105 *Stable Isotope Studies at West Antarctic ITASE Sites*

Original Start Date:**Dec 01, 2000** Projected Duration:**60 Months**
PI: **Steig** Institution: **U of Washington** State:**Washington**

This collaborative proposal supports a project to perform stable isotope analyses of samples collected along the International Trans-Antarctic Scientific Expedition (ITASE) traverses which will begin during the 1999/2000 Antarctic field season. This work will focus on the spatial and temporal distribution of oxygen-18 and deuterium in West Antarctica (where data are particularly sparse) and the calibration of the isotope-climate relationship on a site-by-site basis, using instrumental and remote-sensing temperature histories. Specific objectives of this work which contribute to ITASE are: 1) to obtain detailed oxygen-18, deuterium and deuterium excess and stratigraphic histories in snowpits at most or all of the ITASE coring sites; 2) to provide direct calibration of the isotope-climate relationship at each site through a combination of direct (AWS) and indirect (passive microwave satellite) temperature measurements; 3) to obtain isotope profiles covering the last 200 years; and 4) to use the results to provide 200-year climate histories at high temporal and broad spatial resolution across West Antarctica that will allow testing of proposed relationships among isotopes, moisture source conditions, synoptic scale climatology, and site-specific meteorological parameters, and which will enhance our ability to interpret isotope records from older and deeper Antarctic ice cores.

0126492 *Science Management of the National Ice Core Laboratory*

Original Start Date:**Jan 15, 2002** Projected Duration:**60 Months**
PI: **Twickler** Institution: **U of New Hampshire** State:**New Hampshire**

This award supports the continuation of the Science Management Office (SMO) for the National Ice Core Laboratory (NICL). The NICL-SMO is located at the Institute for the Study of Earth, Oceans and Space at the University of New Hampshire and serves as the primary point of contact for scientists interested in access to ice cores. It also facilitates the interactions of the Ice Core Working Group (ICWG), a group of scientists knowledgeable about ice cores who provide guidance to funding agencies on topics related to sample access, distribution, inventory, policy issues, operation and maintenance of the NICL facility and future directions for ice core research. NICL-SMO assists the ICWG in polling the scientific community and in developing reports, planning workshops and coordinating educational outreach activities. Increasing public and scientific interest in ice cores and ice core records and the growing demand for information about current and past climate all point to the immense importance of this field and the need for this function. Under this renewal award the NICL-SMO will start to publish a bi-yearly newsletter to inform the science community and the general public about the latest findings from ice cores and other news of interest to people curious about ice cores and the paleoclimate records they provide.

0126343 *Cosmogenic Radionuclides in the Siple Dome Ice Core*

Original Start Date:**Mar 01, 2002** Projected Duration:**36 Months**
PI: **Nishiizumi** Institution: **U of Cal Berkeley** State: **California**

This award supports a three-year renewal project to complete measurement of cosmogenic nuclides in the Siple Dome ice core as part of the West Antarctic ice core program. The investigators will continue to measure profiles of Beryllium-10 (half-life = 1.5x10 6 years) and Chlorine-36 (half-life = 3.0x10 5 years) in the entire ice core which spans the time period from the present to about 100 kyr. It will be particularly instructive to compare the Antarctic record with the detailed Arctic record that was measured by these investigators as part of the GISP2 project. This comparison will help separate global from local effects at the different drill sites. Cosmogenic radionuclides in polar ice cores have been used to study the long-term variations in several important geophysical variables, including solar activity, geomagnetic field strength, atmospheric circulation, snow accumulation rates, and others. The time series of nuclide concentrations resulting from this work will be applied to several problem areas: perfecting the ice core chronology, deducing the history of solar activity, deducing the history of variations in the geomagnetic field, and studying the possible role of solar variations on climate. Comparison of Beryllium-10 and Chlorine-36 profiles in different cores will allow us to improve the ice core chronology and directly

compare ice cores from different regions of the globe. Additional comparison with the Carbon-14 record will allow correlation of the ice core paleoenvironment record to other, Carbon-14 dated, paleoclimate records.

0126286 *Continuous High Resolution Ice-Core Chemistry using ICP-MS at Siple Dome*

Original Start Date:**Apr 01, 2002** Projected Duration:**12 Months**
PI: **McConnell** Institution:**U of Nevada Desert Research Inst.**
State:**Nevada**

This award provides one year of support to use newly developed technology in which an ice-core melter is coupled with both an Inductively Coupled Plasma - Mass Spectrometer (ICP-MS) and a traditional Continuous Flow Analysis (CFA) system, to measure a continuous time series of chemical and trace element deposition on the Siple Dome ice core from West Antarctica. A coupled ice-core melter, ICP-MS, and CFA system will be used to measure concentrations of a number of elements, isotopes and chemical species at very high depth resolution (~2-cm) in the top 54 m of the Siple Dome A-core. Pilot data from analyses of ~6 m from the nearby but much lower accumulation J-core site at Siple Dome, together with more extensive results from Summit, Greenland, indicate that it will be possible to obtain exactly co-registered, high-quality records of at least 12 seasonally varying elements (sodium, magnesium, aluminum, potassium, calcium, iron, manganese, rubidium, strontium, zirconium, barium, lead) and three other chemical species and ions (ammonium, nitrate, calcium ion) with this system. Under this proposed research, we will also add continuous measurements of sulfate to our system. Because more than sufficient core from Siple Dome for these depths is archived at the National Ice Core Laboratory, the proposed research will require no fieldwork. The continuous, very high-resolution, ~350-y record of these elemental tracers will enhance the value of previous chemical and isotopic measurements that have been made on the Siple Dome core and will be particularly valuable for comparisons between ice-core proxies and modern instrumental data related to El Nino-Southern Oscillation (ENSO) as well as for validation of model simulations of atmospheric circulation. These data, and the expertise gained through this research, will be invaluable when this novel chemical analysis technology is eventually applied to deep ice-core records for the study of rapid climate-change events.

0126212 *Physical and Structural Properties of the Siple Dome Core*

Original Start Date:**Apr 01, 2002** Projected Duration:**24 Months**
PI: **Meese** Institution:**USACRREL** State:**New Hampshire**

This award supports a 2-year renewal program to continue research on the physical and structural properties of the Siple Dome ice core. This work will include continued monitoring of the core relaxation process, additional examination of the volcanic ash and dust record preserved in the Siple Dome core and its relationship to the timing and distribution pattern of widespread infall of tephra in the Byrd core, and possible climatic implications, additional thin sectioning of ice from below 800 m to obtain a more accurate picture of the response of the deeper ice to increased deformation and elevated temperatures, and measurements of total air content in the basal debris-bearing ice to evaluate mechanisms by which debris is incorporated at the bed. Especially intriguing are ongoing attempts to resolve the climate record at Siple Dome and to refine the time scale. Currently, we are working to obtain the best possible depth-age scale that utilizes annual layer counting based on visual stratigraphy and ECM in conjunction with the gas record. Many climate-related records from the Siple Dome core have recently been presented showing a possible hiatus at approximately 680 m and a potential major climatic event at around 720 m. However, the layer structure in the Siple Dome core shows reversed inclined layering as high as 559 m and evidence of disturbed and steeply inclined layering in deeper ice. It is critical that we determine whether this kind of structural disturbance has resulted in discontinuities in the climate record or is some other structural artifact that has not impacted the continuity of the record. In addition to conducting further visual examination of the core, we plan to prepare vertical thick sections in several regions of disturbed ice structure to determine if the crystal structure reveals evidence of deformation. Until this is complete, we will not know how deep into the core a continuous climate record exists.

0126194 *Ice Core Records of Atmospheric Carbon Monoxide*

Original Start Date:**Feb 01, 2002** Projected Duration:**24 Months**
PI: **Brook** Institution: **Washington State Univ**
State:**Washington**

This award supports a 2-year renewal program to continue research on the physical and structural properties of the Siple Dome ice core. This work will include continued monitoring of the core relaxation process, additional examination of the volcanic ash and dust record preserved in the Siple Dome core and its relationship to the timing and distribution pattern of widespread infall of tephra in the Byrd core, and possible climatic implications, additional thin sectioning of ice from below 800 m to obtain a more accurate picture of the response of the deeper ice to increased deformation and elevated temperatures, and measurements of total air content in the basal debris-bearing ice to evaluate mechanisms by which debris is incorporated at the bed. Especially intriguing are ongoing attempts to resolve the climate record at Siple Dome and to refine the time scale. Currently, we are working to obtain the best possible depth-age scale that utilizes annual layer counting based on visual stratigraphy and ECM in conjunction with the gas record. Many climate-related records from the Siple

Dome core have recently been presented showing a possible hiatus at approximately 680 m and a potential major climatic event at around 720 m. However, the layer structure in the Siple Dome core shows reversed inclined layering as high as 559 m and evidence of disturbed and steeply inclined layering in deeper ice. It is critical that we determine whether this kind of structural disturbance has resulted in discontinuities in the climate record or is some other structural artifact that has not impacted the continuity of the record. In addition to conducting further visual examination of the core, we plan to prepare vertical thick sections in several regions of disturbed ice structure to determine if the crystal structure reveals evidence of deformation. Until this is complete, we will not know how deep into the core a continuous climate record exists.

0126187 *The Thinning of Pine Island Glacier: Model Development and Study of the Importance of Ice-Shelf Drag on Inland Ice*

Original Start Date:**Jan 01, 2002** Projected Duration:**24 Months**
PI: **Alley** Institution:**PA St U University Park**
State:**Pennsylvania**

This award provides support for a 2 year modeling effort to study the dynamics of Pine Island Glacier (PIG). The discharge from the PIG constitutes the largest mass loss from any single West Antarctic ice stream. Satellite observations indicate that this outlet glacier is experiencing ongoing thinning and acceleration. The emphasis of this work will be on understanding the cause and the near-term projection of the observed thinning of PIG. Model experiments will address the hypothesis that the observed changes were caused by the loss of a buttressing ice shelf, and that the changes will continue in the form of an upglacier propagating wave of thinning and acceleration. To perform this work a numerical model of the coupled mass, energy, and momentum balance of Pine Island Glacier basin will be developed. The model will comprise four modular components, which will be coupled and then benchmarked against the European Ice Sheet Modeling Inititative (EISMINT) model intercomparison. The model will then be applied to the thinning of Pine Island Glacier using likely ice-shelf histories and possible basal boundary conditions to learn which may be accurate and to assess possible future behavior. The primary expected result will be an improved understanding of the importance of ice-shelf buttressing and the potential for inland thinning due to the reduction of ice-shelf drag.

0126149 *High-Resolution Modeling of Surface Topography, Ice Motion, and Mass Balance in the Lambert Glacial Basin using Radar Remote Sensing and GIS Techniques*

Original Start Date:**Apr 15, 2002** Projected Duration: **36 Months**

PI: **Liu** Institution: **Texas A&M Research Fdn** State:**Texas**

This award supports a project to characterize the morphology, ice motion velocity and mass balance of Lambert Glacier, Antarctica using state-of-the-art remote sensing and GIS techniques. Lambert Glacier is the largest ice stream in the world. Because of its size, it plays a fundamental role in the study of glacial dynamics and mass budget in response to present and future climate changes. Along with the bedrock topography and ice thickness data derived from airborne radio echo soundings and snow accumulation data compiled from ground-based measurements, the dynamic behavior and mass balance of the Lambert glacial basin in a Geographic Information Systems (GIS) environment will be examined. Specific objectives are to: (1) Extract two-dimensional ice velocity field over the entire Lambert glacial basin using speckle matching and differential interferometric SAR (InSAR) techniques, and produce a full coverage of radar coherence map over the drainage basin. With the ice velocity data, calculate the strain rate field from the initiation areas of the ice stream onto the Amery Ice Shelf; (2) Derive high-resolution digital elevation model (DEM) over the Lambert glacial drainage basin using SAR stereo, differential interferometric SAR, and GLAS laser altimetry techniques. Based on the DEM, extract ice divides and ice flow directions, delineate the snow catchment basin, and calculate the balance deformation velocity and the basal shear stress; (3) Interpolate traverse ice thickness data collected by Australian and Russian airborne radio echo sounding surveys into a regular grid, and derive a regular grid of bedrock topography in combination with the DEM; (4) Integrate newly derived ice velocity and ice thickness data as well as snow accumulation rate data compiled from previous ground-based measurements into a geographic information system (GIS), and calculate the mass flux through the ice stream at the grounding lines and net mass balance throughout the drainage basin. With these new measurements and calculations derived from advanced remote sensing techniques, we will be able to improve our understanding of dynamic behavior and current mass balance status of the Lambert glacial basin, gain an insight on the relationship between ice mass change and the variation in regional and global climate at decadal scale, and provide an evaluation on the issue of whether the Lambert glacier basin is subject to surging in the context of future climate change.

0126057 *High Resolution Records of Atmospheric Methane in Ice Cores and Implications for Late Quaternary Climate Change*

Original Start Date:**Feb 01, 2002** Projected Duration:**48 Months**
PI: **Brook** Institution: **Washington State Univ**
State:**Washington**

This award supports work on trapped gases in Antarctic and other ice cores for paleoenvironmental and chronological purposes. The project will complete a ~ 100,000 year, high-resolution record of atmospheric methane from the Siple

Dome ice core and use these data to construct a precise chronology for climate events recorded by the Siple Dome record. In addition, the resolution of the GISP2 (Greenland) ice core record will be increased in some critical intervals to help with the Siple Dome chronology and that of future ice cores. Finally, an upgrade to the analytical capabilities of the laboratory, including increasing precision and throughput and decreasing sample size needed for ice core methane measurements will be an important goal of this work. The proposed work will contribute to the understanding of the timing of rapid climate change in the Northern and Southern hemispheres during the last glacial period, the evolution of the global methane budget in the late Quaternary, and the late Quaternary climate history of Antarctica. It will also improve our ability to generate methane records for future ice coring projects, and inform and enrich the educational and outreach activities of our laboratory.

0125981 *Generating an Isotopic Record of Atmospheric Methane and Nitrous Oxide Over the Last Century from South Pole Firn Air*

Original Start Date:**Apr 01, 2002** Projected Duration:**24 Months**
PI: **Sowers** Institution: **PA St U University Park**
State:**Pennsylvania**

This award supports a project to construct an isotopic record of atmospheric methane and nitrous oxide over the last century from South Pole firn air. Over the last 150 years, atmospheric methane and nitrous oxide concentrations have risen in response to increased emissions from various anthropogenic activities. As this trend is liable to continue in the foreseeable future, it is important to understand the biogeochemical processes that contribute to the emissions of these two greenhouse gases. In this context, records of the variations in the atmospheric loading of trace gases found in ice cores and interstitial spaces in the snow near the surface of the ice sheet (firn air) provide fundamental boundary conditions for reconstructing historical emission records. One way to improve our understanding of the cycling of bioactive trace gases and their emission records is to use stable isotope tracers, which have been recorded in the ice cores and firn air. This project will develop records of carbon-13 and deuterium isotope ratios of methane, as well as the nitrogen-15, oxygen-18 and the isotopomer composition of nitrous oxide trapped in firn air samples collected in January 2001 at the South Pole. These measurements will allow isotopic records of these atmospheric gases to be reconstructed throughout the 20th century. Such records will help to establish the relative contribution of individual sources with a higher degree of confidence than is currently available.

0125960 *Collaborative Research: Characteristics of Snow Megadunes and their Potential Effects on Ice Core Interpretation*

Original Start Date:**Jul 01, 2002** Projected Duration:**36 Months**

PI: **Shuman** Institution:**NASA-Goddard Space Flight**
State:**Maryland**

This award supports a program of field surveys of an area within the large, well-developed megadune field southeast of Vostok station. The objectives are to determine the physical characteristics of the firn across the dunes, including typical climate indicators such as stable isotopes and major chemical species, and to install instruments to measure the time variation of near-surface wind and temperature with depth, to test and refine hypotheses for megadune formation. Field study will consist of surface snowpit and shallow core sampling, ground penetrating radar (GPR) profiling, GPS topographic and ice motion surveys, AWS installation, accumulation/ ablation measurements, subsurface temperature, and firn permeability studies. Field work in two successive seasons is proposed. Continent-wide remote sensing studies of the dunes will be continued, using the new group of instruments that are now, or will shortly be available (e.g., MODIS, MISR, GLAS, AMSR). The earlier study of topographic, passive microwave, and SAR characteristics will be extended, with the intent of determining the relationships of dune amplitude and wavelength to climate parameters, and further development of models of dune formation. Diffusion, ventilation, and vapor transport processes within the dune firn will be modeled as well. A robust program of outreach is planned and reporting to inform both the public and scientists of the fundamental in-situ and remote sensing characteristics of these uniquely Antarctic features will be an important part of the work. Because of their extreme nature, their broad extent, and their potential impact on the climate record, it is important to improve our current understanding of these. Megadunes are a manifestation of an extreme terrestrial climate and may provide insight on past terrestrial climate, or to processes active on other planets. Megadunes are likely to represent an end-member in firn diagenesis, and as such, may have much to teach us about the processes involved.

0125900 *Constructing the first D/H record of atmospheric methane covering the last two centuries.*

Original Start Date:**Mar 01, 2002** Projected Duration:**24 Months**
PI: **Sowers** Institution: **PA St U University Park**
State:**Pennsylvania**

This award supports a project to improve the understanding of the biogeochemical processes that control CH4 emissions. Records of the concentration of methane in trapped gases in ice tell us about changes in atmospheric loading through time. Such records do not, however, provide information on the individual sources or sinks. One way to refine our

understanding of the cycling of bioactive trace gases like methane is to use stable isotope records of trapped gases in ice cores. This project will measure the Deuterium/Hydrogen (D/H) ratio of methane trapped in shallow/recent ice (covering the last ~ 200 years) at Siple Dome, Antarctica. The proposed work will complement current efforts to measure the carbon-13 isotope ratio of methane in ice cores and will provide fundamental information on the various sources and sinks of atmospheric methane over the last 200 years.

0125794 *Optical Logging for Dust and Microbes in Boreholes in Glacial Ice*

Original Start Date:**Feb 01, 2002** Projected Duration:**36 Months**
PI: **Price** Institution: **U of Cal Berkeley** State:**California**

This award supports research in climatology, geosciences, and life in extreme environments to be carried out with a newly developed optical borehole logger. The logger fits into a fluid-filled borehole in glacial ice. It emits light at 370 nm in a horizontal plane in order to probe optical properties of particles embedded in the ice out to several meters from the borehole. After leaving the borehole, the light is partially absorbed and scattered by dust, biomolecules, or microbes. A fraction of the light is scattered back into the borehole and is detected by a system of seven phototubes, each of which collects light with high efficiency in a separate wavelength band. One of them collects light that scatters off of dust and air bubbles without wavelength shift, and serves as a dust logger. The other six are covered with notch filters that measure six different wavelength bands and measure the shape of the fluorescence spectrum of microbes and biomolecules. Thus, the same instrument serves as both a dust logger and a microbe logger. Applications include: 1) Precise chronologies and long-period solar variability. With a resolution of 1 to 2 cm for both GISP2 and Siple Dome, the logger will record annual dust maxima and evaluate claims of modulations of dust concentration with periods ranging from 11 yrs (the solar cycle) to 2300 yrs; 2) Volcanism and age-depth markers. Dozens of volcanic ash bands will be detectable and will serve as primary age-depth markers for other boreholes; 3) Microorganisms and biomolecules. The vertical distribution of living, dormant, and dead microbes can be logged, and searches for archaea and aeolian polyaromatic hydrocarbons can be made. The logging experiments will be carried out at Siple Dome and Dome C in Antarctica and at GISP2 and GRIP in Greenland.

0125761 *South Pole Atmospheric Nitrate Isotopic Analysis (SPANIA)*

Original Start Date:**May 01, 2002** Projected Duration:**36 Months**
PI: **Thiemens** Institution: **U of Cal San Diego** State:**California**

This award supports a detailed laboratory analysis of the mass-independent isotopic composition of processes associated with atmospheric nitrate trapped in the snow pack at the South Pole. The project will specifically test if the oxygen isotopes ^{16}O, ^{17}O, ^{18}O of nitrate can be used to probe the denitrification of the Antarctic stratosphere. Despite decades of research, there are several important issues in Antarctic atmospheric science, which are presently inadequately resolved. This includes quantification over time of the sources of nitrate aerosols. Today, little is known about the past denitrification of the stratosphere in high latitude regions. This lack of knowledge significantly limits our ability to understand the chemical state of ancient atmospheres and therefore evaluate present and past-coupled climate/atmosphere models. The role of nitrogen in environmental degradation is well known. This issue will also be addressed in this proposal. Atmospheric aerosols have now been shown to possess a mass-independent oxygen isotopic content. The proposed research will investigate the stable oxygen isotope ratios of nitrate in Antarctica both collected in real time and from the snow. Two periods of time will be covered. Full year nitrate aerosol collections, with week resolution time horizons, will be performed at the South Pole. Weekly aerosol collections will help us to identify any seasonal trend of the oxygen-17 excess anomaly, and eventually link this anomaly to the denitrification of the Antarctic stratosphere. This data set will also be used to test our assumption that the oxygen isotopic anomaly of nitrate is mainly formed in the stratosphere and is well preserved in the snow pack. If true, we will for the first time resolve an atmospheric signal extracted from a nitrate profile. The snow pit will allow us to see any trend in the data on a multiple decade timescale.

0125754 *Ice-Shelf Rift Propagation: Computational Simulation Using a Fracture Fracture Mechanics Approach*

Original Start Date:**Apr 01, 2002** Projected Duration:**36 Months**
PI: **Hulbe** Institution: **Portland State University** State:**Oregon**

This award supports a project to develop computational models to simulate ice-shelf rift propagation using a combination of well-established ice-shelf creep-flow models and new crevasse models, based on linear elastic fracture mechanics (LEFM). The overall objective of the proposed work is to simulate rift propagation and eventual large iceberg calving,and place those processes within a larger ice sheet and climate context. The work will proceed in stages, first developing models of single-and multiple-crevasse propagation; then using those models to evaluate propagation sensitivity to various environmental conditions; and third developing models that incorporate both crevasse propagation and advection within an ice- shelf system. Model development will be guided by and evaluated according to satellite observations of rift propagation in several characteristic locations on Antarctic ice shelves. New numerical models of fracture in ice will have applications to many problems in glaciology. The research proposed here is directed toward large rift formation in ice shelves and subsequent iceberg

calving. It is motivated by the need to understand observed changes in modern ice shelves,and their connection to climate. Where it has been sampled, the sedimentary record of the Weddell Sea sector implies Peninsular ice shelf variability on millennial time scales. The ability to simulate iceberg calving in a credible way will improve our ability to reproduce such events and place the complete cycle of ice shelf advance and retreat in an ice-dynamics context. That will, in turn, enable us to place ice-shelf cycles within the climate cycles that ultimately drive ice-sheet mass balance.

0125610 *Model Investigations of the Transition from Inland to Ice Stream Flow*

Original Start Date:**Feb 15, 2002** Projected Duration:**36 Months**
PI: **Waddington** Institution:**U of Washington** State:**Washington**

This award provides three years of funding to study the transition from slow inland flow to fast ice stream flow by making use of a suite of geophysical measurements that have been made near the onset region of ice stream D in West Antarctica. These data provide a unique opportunity to develop and validate glaciological models of the controlling processes in ice stream onset zones. Important processes to quantify are motion at the bed and deformation in the ice. Previous analyses indicate that the controlling resistive forces shift from the bed to the sides during the transition from slow inland flow to fast, streaming flow. Model sensitivity analyses will be used to investigate the relative importance of feedbacks between basal processes and ice deformation in the transition from inland to ice stream flow. Model experiments will determine what factors control the location of the onset of streaming flow, and how that location might migrate when conditions at the bed, or along the flow direction, changes over time. The overall goal of this work is to improve understanding of the evolution of the WAIS drainage system. This study is a first step towards understanding the physics that govern the transition from slow inland flow to fast streaming flow.

0125570 *Collaborative Research: Characteristics of Snow Megadunes and their Potential Effects on Ice Core Interpretation*

Original Start Date:**Jul 01, 2002** Projected Duration:**36 Months**
PI: **Scambos** Institution:**U of Colorado Boulder** State:**Colorado**

This award supports a program of field surveys of an area within the large, well-developed megadune field southeast of Vostok station. The objectives are to determine the physical characteristics of the firn across the dunes, including typical climate indicators such as stable isotopes and major chemical species, and to install instruments to measure the time variation of near-surface wind and temperature with depth, to test and refine hypotheses for megadune formation. Field study will consist of surface snowpit and shallow core sampling, ground

penetrating radar (GPR) profiling, GPS topographic and ice motion surveys, AWS installation, accumulation/ ablation measurements, subsurface temperature, and firn permeability studies. Field work in two successive seasons is proposed. Continent-wide remote sensing studies of the dunes will be continued, using the new group of instruments that are now, or will shortly be available (e.g., MODIS, MISR, GLAS, AMSR). The earlier study of topographic, passive microwave, and SAR characteristics will be extended, with the intent of determining the relationships of dune amplitude and wavelength to climate parameters, and further development of models of dune formation. Diffusion, ventilation, and vapor transport processes within the dune firn will be modeled as well. A robust program of outreach is planned and reporting to inform both the public and scientists of the fundamental in-situ and remote sensing characteristics of these uniquely Antarctic features will be an important part of the work. Because of their extreme nature, their broad extent, and their potential impact on the climate record, it is important to improve our current understanding of these. Megadunes are a manifestation of an extreme terrestrial climate and may provide insight on past terrestrial climate, or to processes active on other planets. Megadunes are likely to represent an end-member in firn diagenesis, and as such, may have much to teach us about the processes involved.

0125560 *Collaborative Research: A 700-Year Tephrochronology of the Law Dome Ice Core, East Antarctica*

Original Start Date:**Feb 01, 2002** Projected Duration:**36 Months**
PI: **Zielinski** Institution:**University of Maine** State:**Maine**

This award supports a project to analyze samples from the Law Dome ice core for volcanic tephra. The Law Dome ice core is the best-dated ice core from East Antarctica and contains a detailed record of climate and atmospheric chemistry over at least the last 700 years. Several global volcanic eruptions appear to be recorded in the Law Dome core, including the well known Tambora 1815 and Unknown 1809 events, as well as the Huaynaputina 1600 and Ruiz 1595 events. To verify the source eruptions responsible for these signals, as well as to differentiate between local Antarctic and southern hemisphere eruptions, a continuous scan for volcanic glass at an annual resolution will be done on the last 700 years of the Law Dome ice core. Sub-annual tephra analyses will be done in the sections containing the largest acid signals in the core. To better evaluate the climatic impact of large equatorial eruptions from ice cores, it is necessary to isolate local eruptions and their associated glaciochemical signal from that of these more distant sources. The identification of local eruptions in the Law Dome core will improve upon the existing chronology of Antarctic volcanism over the last 700 years through the presence of volcanic glass in conjunction with the results from this same type of study on the Siple Dome ice core.

0125549 *Collaborative Research: A 700-Year Tephrochronology of the Law Dome Ice Core, East Antarctica*

Original Start Date:**Feb 01, 2002** Projected Duration:**36 Months**
PI: **Dunbar** Institution: **NM Inst of Mining & Tech** State:**New Mexico**

This award supports a project to analyze samples from the Law Dome ice core for volcanic tephra. The Law Dome ice core is the best-dated ice core from East Antarctica and contains a detailed record of climate and atmospheric chemistry over at least the last 700 years. Several global volcanic eruptions appear to be recorded in the Law Dome core, including the well known Tambora 1815 and Unknown 1809 events, as well as the Huaynaputina 1600 and Ruiz 1595 events. To verify the source eruptions responsible for these signals, as well as to differentiate between local Antarctic and southern hemisphere eruptions, a continuous scan for volcanic glass at an annual resolution will be done on the last 700 years of the Law Dome ice core. Sub-annual tephra analyses will be done in the sections containing the largest acid signals in the core. To better evaluate the climatic impact of large equatorial eruptions from ice cores, it is necessary to isolate local eruptions and their associated glaciochemical signal from that of these more distant sources. The identification of local eruptions in the Law Dome core will improve upon the existing chronology of Antarctic volcanism over the last 700 years through the presence of volcanic glass in conjunction with the results from this same type of study on the Siple Dome ice core.

0125468 *Argon and nitrogen isotope measurements in the Vostok ice core as aconstraint on phasing of CO2 and temperature changes*

Original Start Date:**Jan 01, 2002** Projected Duration:**36 Months**
PI: **Severinghaus** Institution:**U of Cal SD. Scripps Inst** State:**California**

This award supports the continued measurements of gas isotopes in the Vostok ice core, from Antarctica. One objective is to identify the phasing of carbon dioxide variations and temperature variations, which may place constraints on hypothesized cause and effect relationships. Identification of phasing has in the past been hampered by the large and uncertain age difference between the gases trapped in air bubbles and the surrounding ice. This work will circumvent this issue by employing an indicator of temperature in the gas phase. It is argued that 40Ar/39Ar behaves as a qualitative indicator of temperature, via an indirect relationship between temperature, accumulation rate, firn thickness, and gravitational fractionation of the gas isotopes. The proposed research will make

nitrogen and argon isotope measurements on ~ 200 samples of ice covering Termination II (130,000 yr B.P.) and Termination IV (340,000 yr BP). The broader impacts may include a better understanding of the role of atmospheric carbon dioxide concentrations in climate change.

0125276 *Collaborative Research: Characteristics of Snow Megadunes and Their Potential Effect on Ice Core Interpretation*

Original Start Date:**Jul 01, 2002** Projected Duration:**36 Months**
PI: **Albert** Institution:**USACRREL** State:**New Hampshire**

This award supports a program of field surveys of an area within the large, well-developed megadune field southeast of Vostok station. The objectives are to determine the physical characteristics of the firn across the dunes, including typical climate indicators such as stable isotopes and major chemical species, and to install instruments to measure the time variation of near-surface wind and temperature with depth, to test and refine hypotheses for megadune formation. Field study will consist of surface snowpit and shallow core sampling, ground penetrating radar (GPR) profiling, GPS topographic and ice motion surveys, AWS installation, accumulation/ ablation measurements, subsurface temperature, and firn permeability studies. Field work in two successive seasons is proposed. Continent-wide remote sensing studies of the dunes will be continued, using the new group of instruments that are now, or will shortly be available (e.g., MODIS, MISR, GLAS, AMSR). The earlier study of topographic, passive microwave, and SAR characteristics will be extended, with the intent of determining the relationships of dune amplitude and wavelength to climate parameters, and further development of models of dune formation. Diffusion, ventilation, and vapor transport processes within the dune firn will be modeled as well. A robust program of outreach is planned and reporting to inform both the public and scientists of the fundamental in-situ and remote sensing characteristics of these uniquely Antarctic features will be an important part of the work. Because of their extreme nature, their broad extent, and their potential impact on the climate record, it is important to improve our current understanding of these. Megadunes are a manifestation of an extreme terrestrial climate and may provide insight on past terrestrial climate, or to processes active on other planets. Megadunes are likely to represent an end-member in firn diagenesis, and as such, may have much to teach us about the processes involved.

0116674 *Development of a High-Resolution Continuous-Flow Analysis System for Measurements of Soluble Chemical Species in Ice Cores*

Original Start Date:**Aug 01, 2001** Projected Duration:**12 Months**
PI: **Bales** Institution: **U of Arizona** State:**Arizona**

This award supports a Major Research Instrumentation (MRI) Program project for one year of funding to develop a state-of-the-art continuous flow analysis (CFA) system that will be used for measuring concentrations of eight soluble chemical species (calcium, hydrogen peroxide, ammonium, formaldehyde, nitrate, sodium, chloride and sulfate) plus electrical conductivity in polar ice cores. The system will be designed for use in either the laboratory or the field and will consist of a melter (to hold, feed, melt and monitor the core melting progress) and a liquid-flow system to distribute melted samples and mix with reagents. In addition, the system will have a detector to measure the various analytical streams and a data acquisition and processing system for manipulating the large amounts of data that will be produced. While the chemical principles used in the detectors are well established, the design of the overall system and the detailed instrumentation will be entirely new. This new instrument will enable U.S. ice core scientists to remain at the forefront of technology and will increase the quality and rate at which new ice core records can be produced. The access to new ice core records which will be produced by this instrument should result in a better understanding of climate and atmospheric chemistry.

0296099 *Collaborative Research: Discharge Variability of Ross Ice Streams Over the Last Millennium, Deduced by Numerical Simulation of Flow Features in the Ross Ice Shelf*

Original Start Date:**Aug 31, 2001** Projected Duration:**36 Months**
PI: **Hulbe** Institution:**Portland State University** State:**Oregon**

This award supports the investigation of the discharge variablility of Ross Ice Streams over the last millenium, using a combination of numerical simulation and satellite remote sensing of flow features on the Ross Ice Shelf. The proposed collaborative research will use the Ross Ice Shelf record of flow variability to deduce variations in ice stream discharge over the last 1000 years. Changes in ice stream discharge disrupt flow of the ice shelf, in both profound and subtle ways, distorting flow features and changing crevasse patterns. The result in an integrated record of many changes over the lifetime of the ice within the shelf. Interpretations of flow-trace and crevasse geometry already made by Fahnestock and others will be used as a template for the design of numerical modeling experiments. The primary objectives are to verify the imagery existing concepts of ice stream dishcarge variability and will produce new data sets, both which will be use to the Antarctic glaciology community. Landsat-7 imagery will be used to measure velocity in areas of particular interest where existing data are inadequate. MODIS data, which has better radiometric and spatial resolution will be used to improve feature mapping on the ice shelf in sensitive areas.

0226535 *Collaborative Research: Characterizing the Onset of Ice Stream Flow: A Ground Geophysical Field Program*

Original Start Date:**Apr 01, 2002** Projected Duration:**0 Months**
PI: **Anandakrishnan** Institution:**PA St U University Park**
State:**Pennsylvania**

This award supports a four year project to develop of better understanding the ice streams of the Ross Sea Embayment (A--F) which drain the interior West Antarctic Ice Sheet (WAIS) by rapidly moving vast quantities of ice to the calving front of the Ross Ice Shelf. The project will examine the role of these ice streams as buffers between the interior ice and the floating ice shelves. The reasons for their fast flow, the factors controlling their current grounding-line-, margin-, and head-positions are crucial to any attempt at modeling the WAIS system and predicting the future of the ice sheet. For the Antarctic ice streams of the Siple Coast, the transition from no-sliding (or all internal deformation) to motion dominated by sliding is defined as the "onset-region". To fully understand (and adequately model) the WAIS, this onset region must be better understood. The lateral margins of the ice streams are also a transition that need better explanation. Hypotheses on controls of the location of the onset region range from the "purely-glaciologic" to the "purely-geologic. Thus, to model the ice sheet accurately, the basal boundary conditions (roughness, wetness, till properties) and a good subglacial geologic map, showing the distribution, thickness, and properties of the sedimentary basins, are required. These parameters can be estimated from seismic, radar, and other geophysical methods. The transition region of ice stream D will be studied in detail with this coupled geophysical experiment. In addition, selected other locations on ice streams C & D will be made, to compare and contrast conditions with the main site on ice stream D. Site-selection for the main camp will be based on existing radar, GPS, and satellite data as well as input from the modeling community.

0220920 *Workshop on Interdisciplinary Polar Research Based on Fast Ice-Sheet Drilling - FASTDRILL; Santa Cruz, CA, October, 2002*

Original Start Date:**May 01, 2002** Projected Duration:**12 Months**
PI: **Tulaczyk** Institution:**U of Cal Santa Cruz** State:**California**

This award provides partial support for an interdisciplinary workshop to bring biologists, geologists, glaciologists and paleoclimatologists together to discuss the various scientific studies that could benefit from the development of a new, fast and mobile drilling technology for accessing the base of the polar ice sheets. Some of the scientific applications which have been mentioned which would be made possible by such technology include opening of access to subglacial lakes,

detection of life in ancient ice, borehole paleothermometry, site selection for deep ice cores, logging of climate proxies with geophysical tools, ice rheology studies, investigation of basal conditions and their control on basal sliding, sampling of subglacial geology and geothermal heat flow measurements. This workshop will provide a forum for discussions with experts in ice drilling, conventional drilling and downhole sampling systems and will lead to the formulation recommendations to NSF for future directions in rapid access drilling technology. This workshop will contribute to research on sub-glacial lakes in Antarctica, such as Lake Vostok. Prior to the initiation of a research program to study the interrelationship among geologic history, glaciology and biology in sub-glacial lakes, it is necessary to make progress on sampling, measurement and contamination control technologies so that the Lake can be sampled in order to maintain sample integrity in an environmentally sound manner. This workshop will contribute to technology development that will have application to the study of subglacial lakes.

0225992 *Collaborative Research: Characteristics of Snow Megadunes and their Potential Effects on Ice Core Interpretation*
Original Start Date:**Jul 01, 2002** Projected Duration:**36 Months**
PI: **Fahnestock** Institution:**U of New Hampshire** State:**New Hampshire**

This award supports a program of field surveys of an area within the large, well-developed megadune field southeast of Vostok station. The objectives are to determine the physical characteristics of the firn across the dunes, including typical climate indicators such as stable isotopes and major chemical species, and to install instruments to measure the time variation of near-surface wind and temperature with depth, to test and refine hypotheses for megadune formation. Field study will consist of surface snowpit and shallow core sampling, ground penetrating radar (GPR) profiling, GPS topographic and ice motion surveys, AWS installation, accumulation/ ablation measurements, subsurface temperature, and firn permeability studies. Field work in two successive seasons is proposed. Continent-wide remote sensing studies of the dunes will be continued, using the new group of instruments that are now, or will shortly be available (e.g., MODIS, MISR, GLAS, AMSR). The earlier study of topographic, passive microwave, and SAR characteristics will be extended, with the intent of determining the relationships of dune amplitude and wavelength to climate parameters, and further development of models of dune formation. Diffusion, ventilation, and vapor transport processes within the dune firn will be modeled as well. A robust program of outreach is planned and reporting to inform both the public and scientists of the fundamental in-situ and remote sensing characteristics of these uniquely Antarctic features will be an important part of the work. Because of their extreme nature, their broad extent, and their potential

impact on the climate record, it is important to improve our current understanding of these. Megadunes are a manifestation of an extreme terrestrial climate and may provide insight on past terrestrial climate, or to processes active on other planets. Megadunes are likely to represent an end-member in firn diagenesis, and as such, may have much to teach us about the processes involved.